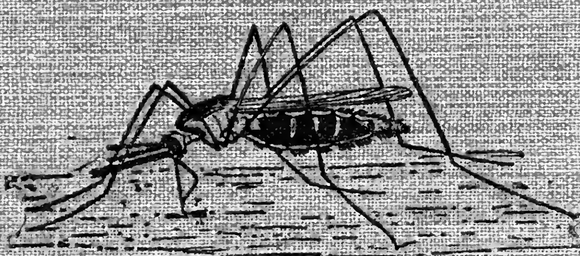

MORE MINOR HORRORS

Mosquitos in the Colvith River delta, Arctic Alaska, about 71° lat., July 1909. The Eskimo, Natkusiak, had stood still for a minute or two, and refrained from brushing them off, while loading a uomiak. (From the *American Museum Journal.*)

[*Frontispiece*]

MORE
MINOR HORRORS

BY

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IN THE UNIVERSITY

ILLUSTRATED

LONDON
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1916

EDMUNDO ALFREDO CARRINGTON

ET

JOHANNI TRISTRAM YARDE

COLLEGII CHRISTI DILECTISSIMIS ALUMNIS

HUIC AB ORIENTI ILLI AB OCCIDENTI PARTE

PRO PATRIA PUGNANTIBUS

PREFACE

My publisher tells me that this volume will be regarded as a sequel to 'The Minor Horrors of War,' and he assures me that sequels are not a success. I have no doubt my publisher is right, because if publishers were not invariably right, and authors invariably wrong, how can one explain the fact that publishers are proverbially prosperous and prominent people, whereas authors are notoriously penniless and obscure? In spite of his warning, however, I propose to publish this little volume, for there still 'air some catawampous chawers in the small way, too, as graze upon a human pretty strong'—as 'one of them inwading conquerors at Pawkins's' called them—that were unmentioned in my earlier book.

I am indebted to the kindness of the Editor and Proprietors of the *British Medical Journal* for permission to reprint Chapters I to IX and Chapter XI, and to the Editor of *The*

Journal of Economic Biology for permission to reprint the twelfth chapter, of this book, and I offer them my thanks. I also thank Mr. Hugh Scott (the University Curator in Entomology), and Professor G. H. Carpenter of the Royal College of Science, Dublin, for much kindly help.

A E. SHIPLEY.

CHRIST'S COLLEGE LODGE, CAMBRIDGE,
April 1916.

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ILLUSTRATIONS

MORE MINOR HORRORS

CHAPTER I

COCKROACHES (*Periplaneta*)

PART I

The Governess: And, perhaps, Mabel, as they are not black and as they are not beetles, you will in future call them cockroaches.

Mabel: Certainly, Miss Smith, although they are not cocks and they are not roaches. (*Punch.*)

IN 'The Minor Horrors of War,' we rather neglected the Navy—the senior Service, and till now the more dominant of our two magnificent forces—partly because it is less interfered with by insect pests than is the sister Service, though the common pests of our poor humanity—the flea, the louse, the bug—are, like the poor, 'always with us.' Like aeroplanes, insects have captured the air; like motors, they have made a respectable show on land; but they have signally failed at sea. They have nothing corresponding to battleships or submarines; and a certain

bug, called *Halobates*, alone hoists the insect

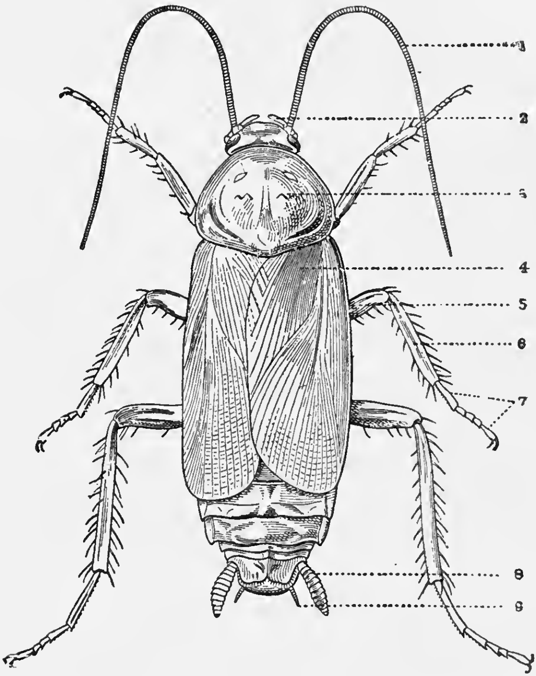

FIG. 1.—*Periplaneta orientalis*, male. × 2. Dorsal view. 1, Antenna; 2, palp of first maxilla; 3, prothorax; 4, anterior wings; 5, femur of second leg; 6, tibia; 7, tarsus; 8, cerci anales; 9, styles. (From Kükenthal.)

flag on the ocean, and that only in the warmer waters.

Insects are not only highly intelligent animals, but are by far the most numerous and dominant class of the Animal Kingdom;

and they have probably come to conclusions about themselves and the sea, comparable to those expressed by Dr. Johnson about man and the ocean: ‘To all the inland inhabitants of every region the sea is only known as an immense diffusion of waters, over which men pass from one country to another, and in which life is frequently lost.’

But one insect at least causes more trouble to sailors than to soldiers—and that is the cockroach. Like the bed-bug, the cockroach came into England at the end of the sixteenth century, and, like the bed-bug, it came from the East. It seems to have been first introduced into England and Holland in the spacious times of Henry VIII by the cross-sea traffic, and from about the end of the sixteenth century the cockroach began gradually to spread throughout the Western world. Like the rat, the bed-bug, and the domestic fly, it has become thoroughly acclimatised to human habitations, and is indeed an associate of man. It is very rarely found living apart from some form or other of human activity.

This insect seems to have been first described in England in Moufet's ‘Insectorum Theatrum,’ 1634, and he speaks of it as living in flour-mills, wine-cellars, &c., in England, and he tells us how Sir Francis Drake took,

in 1584, the *San Felipe*, a Spanish East Indiaman, laden with spices and burdened with a great multitude of flying cockroaches on board.

This species was *Periplaneta orientalis*; but there is another and a larger species, which presumably came into England from the West later than its Eastern cousin *P. americana*—which can frequently be seen in England running about in the cages in our zoological gardens—but it is not on exhibition, it is a by-product, and is not counted in the fee for admission to the gardens.

Latter tells us there are ten species of Blattodea which occur in Britain; but only three of these are indigenous, and these three all belong to the genus *Ectobia*. *Ectobias* are smaller than cockroaches, and do not frequent human habitations, but live in shrubs, under rubbish heaps, &c. Some species of *Ectobia* are, however, very destructive and have been known to destroy in one day the whole accumulation of dried but not properly salted fish in a Lapland village. Of the remaining species of cockroach most are local, and occur sporadically in particular factories, or places where food is stored but they are not very widely spread.

As we have said above, *P. orientalis* is the common English cockroach, *P. americana* occurs especially in zoological gardens and

menageries; but a third species, *P. germanica*, sometimes gets established. Mercifully, *P. germanica* does not seem to spread. Neither *P. germanica* nor *P. americana* seem to make much headway against *P. orientalis*, which appears to be predominant over both these other species.

P. germanica is probably most methodical, very thorough, very brave, very faithful—but rather lacking in the power of understanding the point of view of others. If it has any association with its specific name, it illustrates the most striking example in the world's history of the divorce of wisdom from learning. 'O Lord! give us understanding,' should be the prayer of *P. germanica*.

Miall and Denny tell us that from the first introduction of *P. orientalis* into England it took two centuries before it spread far beyond London. In 1790 Gilbert White speaks of it as 'an unusual insect, which he had never observed in his house till lately,' and, indeed, at the present moment many English villages are still blissfully ignorant of this particular nuisance.

As Fig. 2 shows, the cockroach is a somewhat slackly put together insect. One might almost call it rather slatternly and loose-jointed—and the latter it certainly is. Its head moves freely on the thorax, and the

thorax on the abdomen. The successive seg-

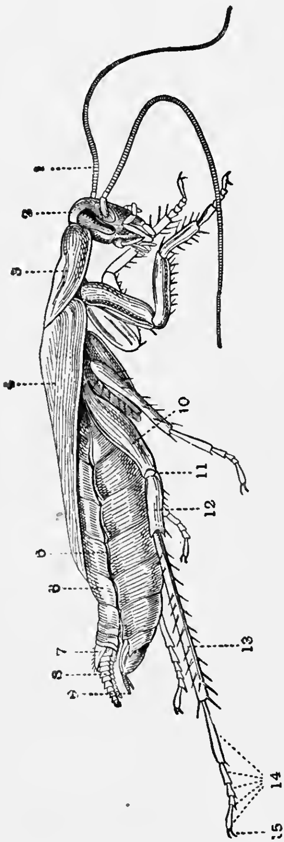

FIG. 2.—*Periplaneta orientalis*, male. × 2. Side view. 1, Antenna; 2, head; 3, prothorax; 4, anterior wing; 5, soft skin between terga and sterna; 6, sixth abdominal tergum; 7, split portion of tenth abdominal tergum; 8, cercianales; 9, styles; 10, coxa of third leg; 11, trochanter; 12, femur; 13, tibia; 14, tarsus; 15, claws. (From Kükenthal.)

ments of the latter move very freely on one another. The legs are long and mobile, and so are the antennae with which the animal is ceaselessly testing the ground over

which it flits hither and thither in its restless activity.

Cockroaches are very difficult to catch. They practically never walk, but run with a hardly believable rapidity, darting to and fro in an apparently erratic mode of progression. Even when caught they are not easily retained, for they have all the slipperiness of a highly polished billiard-ball. They have great powers of flattening their bodies, and they slip out of one's hand with an amazing dexterity. Besides their slipperiness they have another weapon, and that is a wholly unpleasant and most intolerable odour, which is due to the secretion of a couple of glands situated on the back of the abdomen. The glands which produce this repellent odour are sunk in the soft membrane which unites the fifth and sixth abdominal segments, and the moment a cockroach is attacked it exudes a sticky, glue-like fluid, which gives out this most unendurable smell. The fluid is extraordinarily tenacious and difficult to remove from the hand of those who have touched the insects. No doubt the cockroach, in nature, finds safety in this from the attacks of insectivorous animals.

Cockroaches, as has been said, very rarely walk, they nearly always run, and they advance the first and third leg of one side at

the same time as the middle leg of the other, pulling themselves forward with their front legs and pushing themselves forward with the hindermost. They are thus constantly poised on a tripod. They occasionally, but not very often, use their wings for flight. When they do so, their anterior wings are stretched out at right angles to the body, and take no active share in beating the air. They act in effect as monoplanes. It is the hinder wings which really do the active flying. After a flight, the hinder wings are shut up something in the manner of a fan.

The flattened coxae, or thighs, of the leg are adapted for shovelling débris back from beneath the body when the insect is enlarging its habitation. When the cockroach gets into a dusty '*milieu*' the dust is immediately removed; the hairs on the legs act as clothes-brushes and brush every part of the body, whilst the antennae, which attract any dust in the neighbourhood, are repeatedly drawn through the closed mandibles and so cleaned. A cockroach is able to walk on smooth surfaces because it possesses between the joints of the tarsus certain soft, white patches, very velvety, and these give the creature a good hold, and prevent slipping even on glass.

Cockroaches will eat pretty well every-

thing. They are a great nuisance on board ship, where they are said to gnaw the skin and nibble the toe-nails of sailors. Hardly any animal or vegetable substance is absent from their menu. It is said that they will even

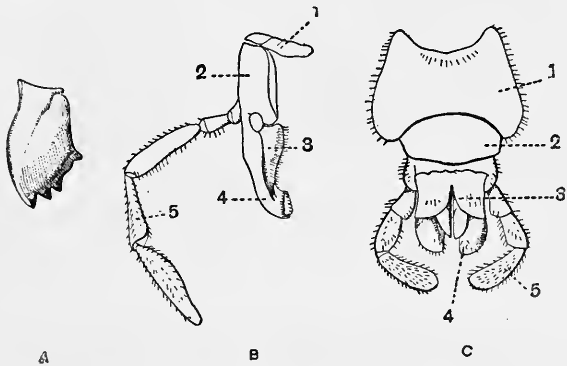

FIG. 3. Mouth appendages of *Periplaneta* (magnified). A, Mandible. B, First maxilla: 1, cardo; 2, stipes; 3, lacinia; 4, galea; 5, palp. C, Right and left second maxillae fused to form the labium: 1, submentum; 2, mentum; 3, ligula, corresponding to the lacinia; 4, paraglossa, corresponding to the galea; 5, palp. (From Latter.)

devour bed-bugs, and that natives on the African shores, troubled by these semi-parasites, will beg cockroaches as a favour from sailors in passing ships.

The mandible (Fig. 3), with its strongly toothed surface, is capable of biting and grinding into fragments a very varied diet. The food is moistened by the secretion of the salivary glands, which is capable of con-

verting starch into the more soluble sugar.

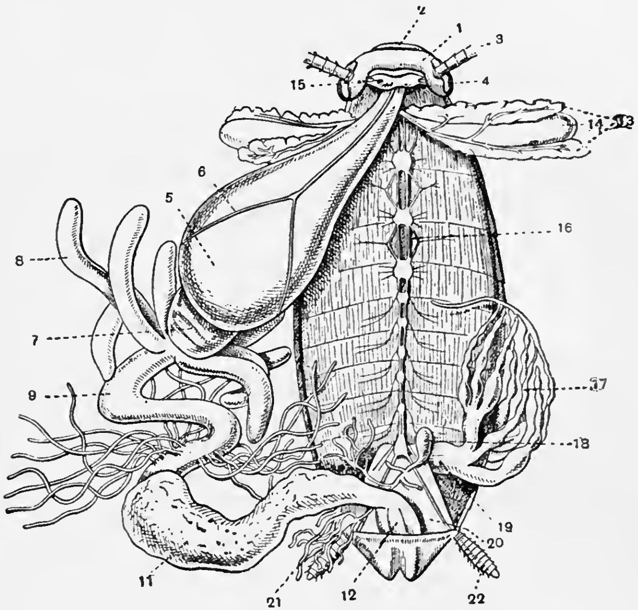

FIG. 4.—A female cockroach, *Periplaneta*, with the dorsal exoskeleton removed, dissected to show the viscera. Magnified about 2. 1, Head; 2, labrum; 3, antenna, cut short; 4, eye; 5, crop; 6, nervous system of crop; 7, gizzard; 8, hepatic caeca; 9, mid-gut or mesenteron; 10, Malpighian tubules; 11, colon; 12, rectum; 13, salivary glands; 14, salivary receptacle; 15, brain; 16, ventral nerve cord with ganglia; 17, ovary; 18, spermatheca; 19, oviduct; 20, genital pouch, in which the egg-cocoon is found; 21, colleterial glands; 22, anal cercus. (From Latter.)

The food is further ground up by a series of hard ridges projecting into the inner face of the gizzard (Fig. 4, 7). The secretion of the so-called hepatic caeca is capable of

emulsifying fat and rendering proteins soluble. Thus the ordinary food substances are reduced to a condition in which they are capable of diffusing from the lumen of the alimentary canal into the blood which floods the body cavity.

The external movement—one might almost say 'the panting'—which is very obvious in the abdomen, the alternate flattening and deepening of this part of the body, is a movement of inspiration and expiration, the air being driven into the stigmata and so into the tracheae or breathing-tubes. There is a considerable variation in the rate of these pulsations, but the cockroach's heart beats at an average rate of seventy to eighty contractions per minute.

Although cockroaches have fairly developed eyes, they seem to trust very largely to tactile impressions in appreciating their relations to the surrounding world. Their antennae and the palps of their first and second maxillae are constantly touching the surface on which they are resting or moving, and from time to time their antennae wildly wave in the air in a manner which suggests that they are smelling out the external circumstances which environ them. The 39,000 sensory 'nerve-endings' which are found in the antennae of the male cockroach are almost certainly olfactory in

function. At the posterior end of the body the two ‘cerci’ are also sensitive to tactile impressions, and probably act at the hinder end of the cockroach as the antennae act at the forward end. Cockroaches are certainly keenly sensitive to light, and, as every one knows, they shun the light, and when detected in daylight or candle-light they make as

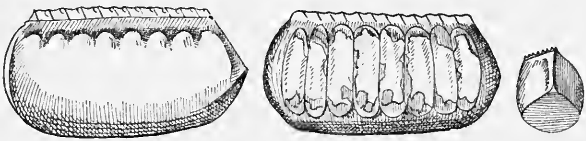

FIG. 5.—Egg capsule of *P. orientalis* (magnified). A, External view; B, opened; C, end view. (From Miall and Denny.)

quickly as they can for some dark hole or crevice in which to hide.

Cockroaches breed during the summer, and their eggs are laid in packets of sixteen in a capsule or cocoon with rounded ends, and with an upper corrugated edge. These cocoons are very like the little hand-bags ladies have carried since the dressmakers denied them pockets. There are sixteen ovarian tubes in the female, and each of these deposits one egg in each cocoon. The ventral portion of the seventh abdominal segment in the female is shaped like the prow of a boat, and it is in this structure that

the cocoon, or egg-case, is built up. Each egg is fertilised by a spermatozoon which has been deposited by the male in the spermatheca of the female. The eggs are placed in a double row, eight in each row, facing each other, and, as they gradually develop, it becomes apparent that the ventral face of one row faces the ventral face of the other row—just as the little choir-boys on the Gospel side of a chancel face the little choir-boys on the Epistle side, but much nearer together—and that their heads are all directed towards the corrugated ridge.

They are at first quite white, but with large black eyes, and it has often struck me how surprised they must be when they awake to consciousness and find themselves staring at a brother or sister cockroach just opposite, of whom they have had hitherto no consciousness. The ripe embryos secrete some fluid, probably saliva, which dissolves the ridge, and it is through this dissolved or softened ridge that they ultimately make their way into the outer world.

Young cockroaches are very active, running about and seeking everywhere for any food of a starchy nature. They are, in fact, miniatures of their parents, for a cockroach, like many of the primitive insects, has a direct development, and there are no such

stages as caterpillar and pupa in their life-history.

But, like other insects, cockroaches change their skin from time to time, and they lose little time before beginning this ecdysis, for they first cast their cuticle immediately after escaping from the egg-capsule. The second ecdysis is four weeks later, and the third at the end of the first year, and after this time they moult annually. At the seventh moult, when the animal is now four years old, it assumes the form of the perfect insect, and is capable of reproduction. The later moults fall in the summer time, and so does fertilisation and oviposition. Male cockroaches may be distinguished from the females by their well-developed wings and wing-covers. They stand higher on their legs than do the females, whose abdomens often trail upon the ground.

In spite of the noxious secretion of their abdominal glands there are creatures who habitually feed on cockroaches—hedgehogs, for instance, are frequently imported into our houses to check these pests. Rats, cats, polecats, frogs, and wasps have been known to eat them, and some few of the digging-wasps lay them down in their larders for the use of their progeny. Some birds will also tackle them. But even the most devoted

friend of cockroaches can find little to say in their favour, except that they are currently reported to form the basis of the flavouring of a very popular sauce; but even wild cockroaches will not drag from me what the name of that particular sauce is.

CHAPTER II

COCKROACHES (*Periplaneta*)

Part II

In Russia the small Asiatic cockroach (*P. orientalis*) has everywhere driven before it its greater congener (*P. germanica*).

(Darwin, *Origin of Species.*)

Cockroaches do a very considerable amount of damage by consuming food-supplies. But they do not stop at food-supplies: woollen clothing, newspapers—not a really great loss—blacking, ink, leather, and even emery-paper, are all to their taste, and, being of an economical frame of mind, they devour their own cast skins and the dead bodies of their relatives. The late Professor Moseley recorded how on one occasion, when on the circumnavigating tour of H.M.S. *Challenger*, a number of cockroaches took up their abode in his cabin and devoured parts of his boots, 'nibbling off all the margins of leather projecting beyond the seams on the upper leathers.' He further records:—

One huge winged cockroach baffled me in my attempts to get rid of him for a long time. I could not discover his retreat. At night he came out and rested on my book-shelf at the foot of my bed, swaying his antennae to and fro, and watching me closely. If I reached out my hand from bed to get a stick, or raised my book to throw it at him, he dropped at once on the deck, and was forthwith out of harm's way. He bothered me much, because, when my light was out, he had a familiar habit of coming to sip the moisture from my face and lips, which was decidedly unpleasant, and awoke me often from a doze. I believe it was with this object that he watched me before I went to sleep I often had a shot at him with a book or other missile as he sat on the book-shelf, but he always dodged and escaped. His quickness and agility astonished me. At last I triumphed by adopting the advice of Captain Maclear and shooting him with a pellet of paper from my air-gun, a mode of attack for which he was evidently unprepared.

It is on record that cargoes of cheeses have been destroyed by cockroaches on ships. Not only did they devour great quantities of each cheese, but they defiled every one of them with their very tenacious fluid which has, as we have noted above, a most disgusting smell. This the cockroaches poured out from their stink-glands, making the cheeses of no commercial value.

When a cockroach casts its skin a median longitudinal slit appears on the back of the

thorax, and through this slit the insect slowly emerges. With much labour and difficulty it squeezes its body through and pulls one limb after another from its old integument, until at last even the long whip-like antennae are completely withdrawn. Certain portions of its inner anatomy—such as the lining of parts of the breathing-tubes, or tracheae—are also withdrawn. Should the discarded skin not be eaten by the emergent insect, it remains on the floor, and might easily be mistaken for a sedentary cockroach but for the fact that live cockroaches never are sedentary.

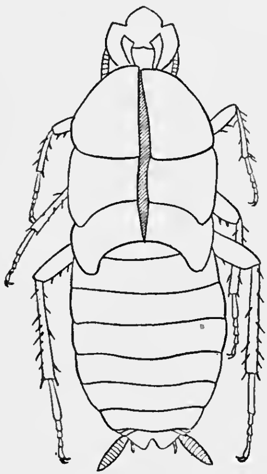

Fig. 6.—Cast skin of older nymph (pupa). × 2½. (From Miall and Denny.)

The incomplete metamorphosis, the generalised character of the nervures of the hind wings, the complete separation of the three thoracic segments (or rather their want of that fusion so conspicuous in the higher insects—the flies and the bees) and the undifferentiated condition of the mouth parts—all point to the insect being of a primitive type. But there is no doubt that, whether a primi-

tive insect or not, the cockroach is a very successful one; it is an *arriviste*—as 'our lively friend, the Gaul,' to quote Mr. Micawber, would say—probably owing to its attaching itself in all cases, and with unvaried devotion to the habitation of men. Not popular with humanity, it nevertheless ceaselessly extends its domain by slowly yet surely entering into

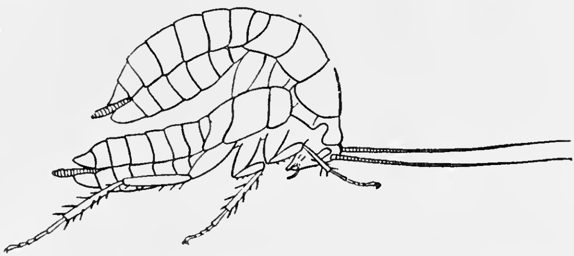

Fig. 7.—Nymph (in last larval stage) escaping from old skin. Magnified. (From Miall and Denny.)

new and hitherto unconquered human habitations. In spite of insect-traps and vermin-killers, it is extremely difficult to eradicate from a house when once it is well established. It has, in fact, gradually dislodged in most places in Great Britain and Ireland the old domestic house-cricket. For in spite of its irritating, and to some people quite maddening, ticking, the 'cricket-on-the-hearth' has somehow established itself as a household pet, and one that has won not only our

respect but our affection. So curious is our psychology.

The cockroach has many enemies, and the genus *Sphex* (or *Chlorion*) may be seen hunting about here and there, up and down the road-side and gardens, searching for its favourite prey. It spies out a cockroach, which appears to know intuitively that there is danger at hand, for it shows symptoms of great fright, and seems so confused that it cannot run away. The *Chlorion* pounces upon the insect, clasps it with its mandibles between the head and the corselet, and stabs it in the body with the sting. Then it flies off for a little distance, and awaits the effects of the poison thus introduced; and when the convulsions of the victim have ceased, the clever little insect seizes its stupefied prey, and drags the heavy burden with great efforts to its nest. Usually the opening of the cavity is so narrow that the cockroach cannot be got in, for its legs and wings stick out and prevent its introduction. But the *Chlorion* sets to work and cuts off the legs and the wings, and having thus lessened the difficulty, it strives hard to push the body into the hole; but as this plan usually fails, the hymenopteron enters first of all, seizes the cockroach with its mandibles, and drags it in with all its force. As the integuments of the *Blatta* are more or less soft and flexible, the great insect is at last forced into the gallery, where it never could have been expected to have entered. Such proceedings on the part of the *Chlorion* almost verge upon the domain of reason; and it is difficult to explain them by the notion of that very indefinite quality called instinct, for the manœuvres vary

according to the circumstances, and there appears to be an intelligent method of overcoming every difficulty.[1]

Apart from animals which eat it, there are a number of parasites which infest it, beginning with the parasitic beetle *Symbius blattarum*, whose wingless females attach themselves to the bodies of the cockroaches and feed upon their tissues. Then occasionally a round-worm, *Filaria rhytipleurites*, whose sexual stage is passed in the rat, is found in its larval stage in the fat bodies of the cockroach.

Two years ago Dr. C. Conyers Morrell undertook some investigations and observations as to what part, if any, cockroaches played in the dissemination of pathogenic microbes, his object being, as he says, 'first to ascertain what bacilli belonging to the colon group are likely to be conveyed to food and milk by this insect, and secondly to find whether known bacteria and moulds can be transmitted by the faeces.' Dr. Conyers Morrell's experiments were conducted on one of the Union Castle liners sailing to South Africa, and the insects which were investigated were collected only from the larder or passages

[1] *The Transformation of Insects*, by P. M. Duncan. London: Cassell, Petter, Galpin and Co., 1882.

adjacent to the kitchens; in no case were they taken from lavatories or from staterooms. The general condition of the ship, which was almost new, was one of exceptional cleanliness, and thus afforded good conditions for the experiments. Dr. Morrell was of opinion that there was little danger except by contamination from the faeces of the infected insect.

One of his first experiments was to prove that should cockroaches fall into the dough which was being baked for bread the heat of the baking entirely destroyed the bacilli that were in the alimentary canal of the insect. With regard to infection with the colon bacillus, he kept an infected insect under the best antiseptic conditions he could compass until it had passed some undigested food. Of this undigested food an emulsion was prepared, and cultures were made from it on bile-salt medium and in litmus-milk. Afterwards special cultures were made in gelatine and peptone solutions. Incubation was conducted in all cases at 37° C., and cultures were made from seventeen specimens. Five of these produced colonies of bacilli on the bile-salt medium, with sub-culture results as follows: Four produced acidity and clotting of milk, acid, and gas in glucose, lactose, and saccharose, and production of indol. But the

bacilli did not liquefy gelatine, and were Gram-negative. One specimen produced gas in glucose and lactose, and liquefied gelatine and coagulated milk. The former in its reaction corresponded to the *Bacillus lactis aērogenes*, the latter to *Bacillus cloacae*. In five cases greenish moulds of the *Aspergillus* variety were found after inoculating litmus-milk.

Cockroaches will devour human sputum with avidity, and are frequently to be found in spittoons (or, as the more delicately minded American calls them, 'cuspidors'[1]), and it is interesting to know that after feeding the insects on infected sputum from a tuberculous patient, the tubercle bacilli are found in the faeces within twenty-four hours; two specimens which had been fed on staphylococci showed these pathogenic organisms in their faeces and in the cultures on agar-agar, which were obtained from their dejecta.

I have quoted largely from this important paper, and now propose to quote a good deal more, and thus I append Dr. Conyers Morrell's conclusion of the important experiments he conducted on the Union Castle liner.

The foregoing experiments, though insufficient in number to afford a basis for working out per-

[1] From the Portuguese 'cuspidor.' Cf. the Latin 'conspuere.'

centage results, are, I think, of some value, in that they prove the following facts :—

The common cockroach is able by contamination with its faeces (1) to bring about the souring of milk; (2) to infect food and milk with intestinal bacilli; (3) to transmit the tubercle bacillus; (4) to disseminate pathogenic staphylococci; (5) to transmit from place to place destructive moulds.

These facts, taken in conjunction with the life-habits of the insect, lead to the conclusion that the cockroach is able to and may possibly play a small part in the dissemination of tuberculosis, and in the transmission of pyogenic organisms; that the insect is in all probability an active agent in the souring of milk kept in kitchens and larders; and that it is undoubtedly a very important factor in the distribution of moulds to food and to numerous other articles, especially when they are kept in dark cupboards and cellars where cockroaches abound. The distribution and numbers of the cockroach are rapidly increasing, and unless preventive measures are adopted the insect is likely in the course of time to become a very troublesome and possibly a very dangerous domestic pest.[1]

[1] *British Medical Journal*, 1911, ii, 1531.

CHAPTER III

THE BOT- OR WARBLE-FLY (*Hypoderma*)

Apropos de bottes.—(Reynard.)

Britain wants many materials in this war, and as long as our back door is open we are getting them. Petrol, rubber, zinc, copper, molybdenum, vanadium, thorium, nickel, saltpetre, wool, cotton, are all coming to us in greater—immeasurably greater—quantities than those in which they can filter through neutral countries into Germany. These things count. The shortage of leeches in Great Britain, on which I have already dwelt, is negligible, and is entirely over-balanced by the really serious shortage of sausage-skins in middle Europe. I am told that our meat-salesmen at Smithfield were offered an incredible advance on the normal rate for these products—so - very - necessary - and - under - no - circumstances - to - be - done - without - with - casements—but the meat-salesmen at Smithfield were patriots. In their dire extremity the Germans have been trying to make them of cellulose.

Amongst the things both combatants most want is leather. One of the most impressive efforts we non-combatants have been watching, since August 1914, is an army growing, near us and next us, with apparently an unlimited supply of leather belts, leather trappings, leather saddlery—leather harness for man and beast. Yet they tell me that the price of leather since the War began has appreciated by 140 per cent. This may be so; but, as Joseph Finsbury remarked in 'The Wrong Box,' 'there is nothing in the whole field of commerce more surprising than the fluctuations of the leather market. Its sensitiveness may be described as morbid.' But Joseph was no business-man, and kept in the background of the office a capable Scot who was understood to have a certain talent for bookkeeping. Readers of Stevenson will remember that nobody had ever made money out of Finsbury Brothers, Leather-merchants, except the capable Scot who retired (after his discharge) to the neighbourhood of Banff, and built a castle with his profits. There are still many capable Scots about, and this may, to some extent, account for the present price of Sam Browne belts.

There must have been well over 150,000 Sam Browne belts made since the War began. A widespread belief—at any rate, amongst

the junior members of the Army—is that Sam Browne was an American; possibly some slight confusion existed in their dear young minds between the inventor of the belt and John Brown whose 'body lies,' &c. The inventor of this useful cincture was, however, Sir Samuel James Browne (1824–1901), G.C.B., K.C.S.I., the well-known Indian fighter, who lost an arm, and gained a V.C. by his gallantry during the Mutiny. He was for a time the military member of the Governor-General's Council, and he commanded the first division of the Peshawar Field Force during the Afghan War of 1878–9. The 22nd Regiment in the Indian Army, a frontier force, is known as Sam Browne's Cavalry.

The belt was first used unofficially, but it gradually found favour with the authorities, and it is mentioned officially in the regulations drawn up for the Straits Settlements in 1891, and for Egypt and West Africa in 1894. It was only on April 24, 1900, that the pattern was 'sealed,' and adopted as a general item of equipment for all officers on Active Service.

Anything that seriously destroys the continuity of the integument of our oxen, which interferes with the 'wholeness' of the hide which is the basis of leather, clearly affects —and affects detrimentally—an important munition of war. The bot- or warble-fly does

this. But it does more : its attacks materially lessen the value of the beef which potentially lies beneath the hide, and thus in a double sense the warble-fly is the enemy of man whether he be soldier or sailor. Further, its attacks seriously lessen the milk-supply of the country.

Amongst the numerous families into which the true flies (DIPTERA) are divided, none are more harmful to human enterprise than that of the *OESTRIDAE*, or bot-flies, inasmuch as every single species and every single member of this family passes its larval stage within the tissues of some vertebrate host, and frequently in those of domesticated cattle ; sometimes even in man himself. One of the commonest genera of this family of flies is *Hypoderma*, which is represented in our islands, and in many other parts of the world where domesticated cattle are reared, by two species—*H. bovis* and *H. lineatum*, both commonly known as bot- or warble-flies.

The harm caused by these larvae, living as they do in the tissues of the body, beneath the skin, by piercing holes through the integument or skin, whereby they make their exit from the 'warble' or subcutaneous tumour in which they have passed their latest larval stage, is almost incalculable.

Miss Ormerod, who for so many years

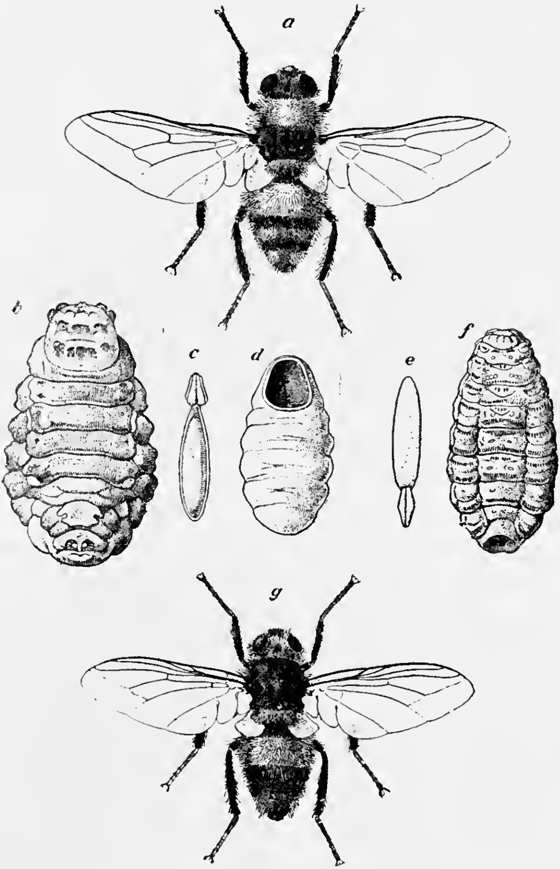

FIG. 8.—*a*, *Hypoderma bovis*; *b*, maggot of *H. bovis*; *c*, egg of *H. bovis*; *d*, puparium of *H. bovis*; *e*, egg of *H. lineatum*; *f*, maggot of *H. lineatum*; *g*, *Hypoderma lineatum*. All the figures are magnified. (From F. V. Theobald's *Second Report on Economic Zoology*, British Museum, 1904.)

kept alight the lamp of economic entomology in England, published some statistics on this subject towards the end of the last century. In 1888, out of slightly over 100,000 hides dealt with in the Newcastle cattle and skin market, 60,000 were 'warbled,' and the loss to the trade amounted to £15,000. The same year at Nottingham 8500 out of 35,000 hides were largely spoiled; at Manchester 83,500 out of 250,000 suffered from the same cause: the losses in these towns being estimated for the year in question at about £2000 and £17,000 respectively. Taking the average from all sources in England, Miss Ormerod estimated the fall in value at from 5*s*. to 6*s*. on every warbled hide. The most riddled hides—that is, those with the most punctures—come to the sale-room during April and May, but the trouble extends from February to September.

There is also the loss caused by the warble to the butcher—and through the butcher to the Army Service Corps. The presence of the fly-larva, which is quite a large creature, induces chronic inflammation in the tissues, and a state of things known to the trade as 'licked beef,' and unless the meat-salesman cuts away the affected parts the meat is unsaleable in the market, or greatly depreciated in value. The average loss to

the butcher on a warbled carcass is estimated at 6*s*. 8*d*.

Finally there is a loss to the stock-raiser and dairy farmer. We shall have occasion later to refer to the curious psychological effect the warble-fly has upon the cattle, causing them to 'gad' or stampede in wild gallops, which interferes with fattening, deteriorates the milk-supply, and is especially injurious to cows with calf. Mr. Imms, in his most useful summary of the warble-fly, tells us that the loss due to *H. lineatum* in America is calculated at 28 per cent. of their total value of all the cattle in the States. Some authorities place the total loss to the agricultural community in England at £2,000,000, others at £7,000,000, a year, whilst others estimate that the loss amounts to about £1 sterling on every head of horned cattle.

Curiously enough, the fly itself is rarely seen, and still more rarely taken. Mr. Imms records only two specimens of *H. bovis* in the collections of the British Museum, and but fifteen of *H. lineatum*. A similar scarcity of imagos in public collections obtains on the other side of the Atlantic, where for many years the last-named species was alone recognised. Two years ago, however, Dr. Hadwen, working in Canada, established the widespread existence of *H. bovis* in the Dominion;

almost certainly it also occurs in the States; but Dr. Hadwen had to send to Dublin for specimens with which to confirm his find. None existed in the collections in Ottawa, and a 'request for a specimen . . . from the Bureau of Entomology at Washington, D.C., could not be granted owing to a scarcity of specimens'! These statements are interesting, since at present the tanneries of Canada are working night and day to help our shortage in leather at home.

H. bovis measures $\frac{5}{8}$ in. in length, *H. lineatum*, somewhat less robust, $\frac{1}{2}$ in.; the hairy covering of the last named is of a foxy red at the tail end, while that of *H. bovis* is yellow, both at the tail end and towards the front of the body. The flies are most abundant during July and August, though they are believed to occur throughout the summer. At Athenry (co. Galway) *H. lineatum* is common by the middle of May. They fly very rapidly, and are difficult to follow with the eye. They rejoice in warm, sunny weather, and remain in retirement during cold or cloudy days. Hadwen describes the egg-laying by the female 'as a sort of frenzied process, the fly striking' with its ovipositor twenty or thirty times rapidly, then leaving the animal for fifteen minutes or so, when the process was repeated. The eggs are

attached one at a time to the hairs of the

Fig. 9.—Eggs of *H. lineatum* attached to hair of cow. Five of the eggs are hatched and six unhatched. Magnified 15 times. (From Carpenter, Hewitt, and Reddin, *Journ. Dept. Agric. Ireland*, xv., 1914.)

cattle and very close to the base of each hair, not near the tip, where the horse bot-fly

deposits its ova. The eggs of *H. bovis* are scattered and isolated; those of *H. lineatum* are arranged in rows of some seven or more half-way up the hair and are contiguous. The favourite region for placing the eggs is on the hock and on the back of the knee, or on the thighs and flanks, and hence the American cowboys call the insect the 'heel-fly.' Undoubtedly by standing with their legs in water the herd is delivered from the pest—at any rate, for the time.

The eggs are large, 1·25 mm. in length, and enclosed in a whitish shell, which is prolonged behind into a brownish foot, and this foot, which exudes some sticky excretion, adheres to the ruminant's hairs. The foot of the egg-shell, in fact, consists of two lobes or valves, which clasp the hair between their sticky inner surfaces.

Within the egg the youngest of the four larval stages is maturing. When hatched it is less than 1 mm. long, but it is 'a terror for its size,' being armed with a formidable spine and two hooks in the mouth, and with rows of strong spines on all the body-segments. Later, we find a second stage, very much smoother and less spiny than the first and this lies within the tissues of the host, embedded in its muscles and membranes, notably in the submucous coat of the gullet; and now the

question confronts us, which once confronted George III apropos of the apple in the apple dumpling, 'How the devil did it get in?' There seems to be with *Hypoderma* but two possible modes of entrance into the body

FIG. 10.—Eggs of *H. bovis* attached to hairs. Note attachment near base. Slightly enlarged. (From Hadwen.)

of its host—that is, domesticated cattle: (1) The eggs, or the newly hatched larvae, are licked up by the tongue, as are the eggs of the horse bot-fly—and this might be held to explain the not infrequent occurrence of the second larval stage in the walls of the oesophagus; or (2) the larvae bore their way directly through the skin. From experiments carried

on for several years which show that cattle unable to lick themselves are not protected from warbles, Professor G. H. Carpenter of the Royal College of Science, Dublin, concluded that the larvae do not enter by the mouth. During the summer of 1914, he and his able assistant, the late Mr. T. R. Hewitt, definitely proved that 'the newly hatched maggot does bore through the skin of cattle'; probably after an ecdysis they find their way to the submucous coat and muscles of the gullet, and here for a while they rest. I quote from the account of Carpenter and Hewitt some of their most crucial experiments carried out at the Athenry and Ballyhaise Stations of the Irish Department of Agriculture :—

In July 1914, twenty-four maggots were hatched in the incubator, and some of these were used for observations as to behaviour when placed on a calf's body. Glaser, in 1913, had tried to carry out observations of this kind by placing maggots on a shaved portion of a calf's skin ; he found that they made no effort to bore through. Instead of being shaved, a small patch of the shoulder of one of the Ballyhaise calves was clipped, so as to have the conditions as normal as possible, when newly hatched maggots of *H. bovis* were placed on it. Immediately they started crawling down the clipped hairs to the skin, and, as soon as they reached the surface, they began to burrow. On account of their small size it is hard to discern them, but by carefully watching

through a lens it was seen that they enter perpendicularly to the surface, evidently cutting into the epidermis with their mouth-hooks and occasionally

Fig. 11.—Entrance hole of *H. lineatum* maggot into the skin of a cow. The hairs around the hole have been clipped short. The white incrustation is due to a discharge from the hole, which has hardened. Magnified 12 times. (From Carpenter, Hewitt, and Reddin, *Journ. Dept. Agric., Ireland*, xv., 1914.)

bending their bodies. Mr. R. G. Whelan, A.R.C.Sc.I., Superintendent of the Ballyhaise Agricultural Station, kindly helped in the observations and confirmed them. Six hours after being placed on the calf, the maggots disappeared completely. Next morning the spots where they had entered were

marked by little pimples, like those of the Athenry animals, easily to be seen with the naked eye. These increased slightly in size, but soon healed up, and in less than a week not a trace of the maggots' entrances could be found. The boring-in of the maggots seemed at first to cause the calf a little pain, but the symptoms of discomfort soon passed away.

We have still to find out what happens to the first-stage larva after it has bored into the skin and how far it travels before it undergoes its first moult. Gläser found that some eggs of *H. lineatum* laid on his trousers hatched, and that a maggot bored right through into his own skin. From symptoms of swelling and pain in various regions he concluded that this maggot travelled to his gullet, and he finally extracted it (in the second stage) from his mouth.[1]

Perhaps in the first stage they may be carried by the blood stream. They seem in their second larval stage to wander freely through the tissues, especially through the muscular tissues, of the body of their host—usually working upwards, and not infrequently reaching the neighbourhood of the vertebral column before taking up—still in the second larval stage—their final position, where their presence gives rise to the 'warbles,' or subcutaneous cysts or tumours, in which the third and fourth larval stages are passed.

[1] *The Irish Naturalist*, October 1914.

It seems odd that an insect pest, which so seriously affects our supply of leather, of meat, and of milk, should have been studied for over a century and yet conceal its chief secret from man. But the problem is much more difficult than the layman thinks.

Whatever be the route the maggot travels through the body of the calf or cow, by the spring the fourth larval stage—when it is about an inch long, and perhaps half as much in breadth—is reached in the 'warble' or cyst, under the skin. Here, nourished by the products of the inflammation it sets up, and breathing by two spiracles at the hinder end of its body, which are directed to the opening of the 'warble' which it has pierced through the skin, the larva rests until one fine morning it pushes its way, aided by its stout bristles, through the opening and tumbles into the outer world.

Apparently it does not think much of its new surroundings, for it loses no time in hiding under some clod of earth or stone or crevice in the soil, and straightway turns into a dark brown pupa or chrysalis. This stage lasts three to four weeks, and then the perfect fly emerges, and will soon be ready to lay her eggs on some new victim.

As a rule it is the yearlings who suffer most, and then the two-year-olds; the older

cattle being comparatively immune. The inexplicable terror which the warble-fly induces in its victims is testified to on all hands, but has never been adequately explained. *Hypoderma* does not bite, neither does it sting.

Fig. 12.—Cow being chased by fly. Note terrified look of eyes. (From Hadwen.)

Many other blood-sucking insects, whose puncture must involve some pain, are tolerated by cattle with a flick of the tail, or are frightened off by a gesture of the head; but the presence of the warble-fly induces a mysterious fear which rapidly spreads through a herd, and results in a general stampede—often referred to by cattle-breeders as the 'gad.' This terror communicates itself even to the

'stalled ox,' and cattle confined within cow-sheds show symptoms of extraordinary unrest when the fly is abroad amongst their kin in the pastures. The resulting evils are, of course, far graver in the unlimited prairies of the West—the great cattle-breeding districts of the United States and Canada—than in our carefully hedged or fenced meadows. A great many 'dips,' ointments, and chemical solutions have been recommended for the prevention of the grubs in cattle, but none have proved entirely satisfactory. The tedious method of removing the grub from the tumour is the only safe one. This can be done by the mere pressure of the fingers when the grub is nearly mature and ready to leave its host, or by the use of small forceps should the grub be young and recalcitrant. Once removed the grub should be immediately destroyed, and some such antiseptic as coal-tar applied to the lips of the vacated tumour

CHAPTER IV

THE MOSQUITO (*Anopheles maculipennis*)

Part I

Where the water is stopped in a stagnant pond,
Danced over by the midge.
(R. Browning, *By the Fireside.*)

There is no zoological distinction between a mosquito, a gnat, or a midge. But, as a matter of convenience, we might confine the term 'gnat' to the genus *Culex*, the term 'mosquito' to the genus *Anopheles*, and the term 'midge' to the genus *Ceratopogon* and its congeners, whose collocation with the naked knees of the Highlander is said to have given rise to the 'Highland Fling.'

There is no doubt about it that both the mosquito and the gnat are extraordinarily beautiful insects. This fact, however, has been veiled from the public partly owing to their small size and more especially because of their irritating bite, which causes the sufferer to kill a mosquito at sight rather than examine its fairylike beauty or its fascinating

dances in the air, far surpassing in grace and agility anything seen in the Russian ballet. But biting is the dominating note of a mosquito, and we may as well consider, to begin with, how it bites.

If we examine the head of a mosquito we shall find that it is shaped like a circular cushion bearing two enormous eyes—so large that in the male they touch above the forehead and almost meet below the chin. Each eye consists of hundreds of facets of a brilliant green hue, set in a darkish background, like emeralds arranged on a black surface. The head also bears a quantity of hairs and flattened scales whose number, shape, and arrangement are of considerable systematic value.

The following are the appendages of the head :—

1. A pair of antennae, which are markedly different in the two sexes.

2. A pair of mandibles. These are absent in the male.

3. A pair of first maxillae, each of which has a jointed tactile palp.

4. A pair of second maxillae which have fused together to form a deeply grooved soft process in which the other appendages lie.

Beside these four pairs of appendages, which are in reality modified limbs, there are two median processes, which project one from

the top, the other from the bottom, of the mouth, like elongated and hardened upper and lower lips. These are the median labrum above—a deeply grooved structure whose edges

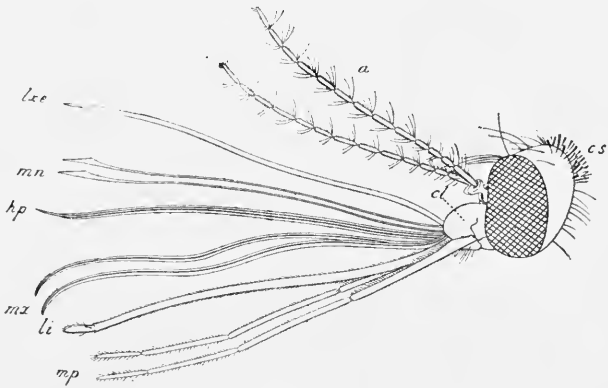

FIG. 13.—Side view of the head of a female *Anopheles maculipennis* (magnification about 20), with the various mouth parts separated, but in the relative position in which they lie when enclosed in the groove of the labium. This figure shows the characteristic cephalic scales. *a*, Antennae; *c.s*, cephalic scales; *cl*, clypeus; *lxe*, labrum + epipharynx; *mn*, mandible; *hp*. hypopharynx; *mx*, first maxilla; *li*, labium; *mp*, maxillary palps. (From Nuttall and Shipley.)

approximate and almost touch, thus forming a tube along which the blood of the victim is sucked. Lastly, there is the hypopharynx—sometimes termed the tongue—a median structure, a double-edged sword, rising from the bottom of the mouth, and it is this that is the cause of all the trouble.

A glance at Fig. 13 will show how these

various mouth appendages can by a skilful use of dissecting needles be separated out, but in nature they are all packed together in a case; the arrangement in the case is shown

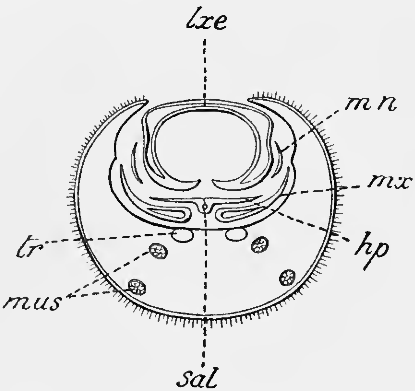

FIG. 14.—Transverse section through the middle of the proboscis of a female *Anopheles maculipennis*, showing the relative position of the parts when at rest. Two tracheae and two pairs of extensor and flexor muscles are seen in the labrum. *lxe*, Labrum + epipharynx; *tr*, trachea; *mus*, muscles; *hp*, hypopharynx; *sal*, salivary duct; *mx*, first maxilla; *mn*, mandible. (From Nuttall and Shipley.)

by Fig. 14, which represents a transvese section of the proboscis. The term 'proboscis' is given to the totality of all these structures taken and packed together. With the exception of the labium and of the tactile maxillary palps all the mouth appendages lance into the skin. The proboscis of the male is, how-

ever, too weak to pierce the human integument, and it is the female which does all the damage. When a mosquito is going to bite, she alights so gently that her approach is unperceived, and she proceeds to thrust her arsenal of weapons into the epidermis of her victim almost unfelt; the feeling comes later. These weapons are all guided, by the forked end of the softened labium, just as one's finger-tips guide the end of a billiard-cue. These 'mouth parts' are exceedingly fine, extremely sharp-edged structures, whose consistency is about that of whalebone, and both the mandibles and the maxillae have a toothed, serrated edge (Fig. 15). They are partly pushed in by muscles in the head, partly, I think, by the lowering of the body, and they sink slowly and surely into the flesh with as much ease as a paper-knife will penetrate a cream-cheese. But as they sink deeper and

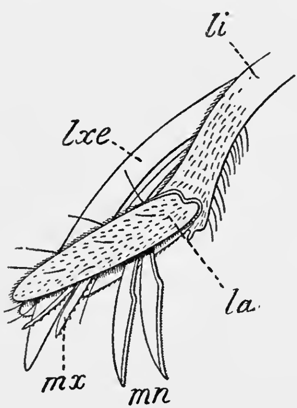

FIG. 15.—A side view of the labellae and piercing-organs of the proboscis of a female *Anopheles maculipennis*, dissected out to show the tips of the mandibles, maxillae, and labrum + epipharynx. The hypopharynx is not shown. *li*, Labium; *lxe*, labrum + epipharynx; *mx*, first maxilla; *mn*, mandible; *la*, labellae. (From Nuttall and Shipley.)

deeper into the integument the body of the mosquito approaches nearer and nearer to the skin of the victim, and the labium is pressed farther and farther backwards until at the end of a satisfactory puncture the distal and proximal parts of the labium are parallel and touching.

It is rather an interesting point that the labium does not enter the skin, because the larvae of certain *Filarias*—one of which produces elephantiasis in man, and the other severe heart trouble in the dog—are found in pairs—probably a male and a female—in the labia of mosquitos. How exactly these nematode larvae leave the labium of the mosquito, and enter the body of the man and the dog, has not definitely, I believe, been cleared up; but that they do enter the human and the canine skin seems certain.

We have mentioned that the labrum is a grooved tube with its edges practically in proximity, and it is up this tube that the blood of the bitten is sucked by the well-known suctorial pharynx which occupies so large a part of the interior of the head of a mosquito. Much the most dangerous weapon of the whole armoury, however, is the hypopharynx. This is shaped like a double-edged sword with a very minute groove running down the centre; this groove is so minute that Professor Nuttall and I and others for some time took it to be a

closed tube. It receives at its base the products of the salivary glands of the mosquito, and it is these products which contain the organisms which cause malaria—a disease which has probably caused more trouble and has played a greater part in the history of the world than any other malady to which humanity is heir. Down this minute, microscopic groove has flowed the fluid which has closed the continent of Africa for countless centuries to civilisation, and which has played a dominating part in destroying the civilisations of ancient Greece and of Rome.

When the adult mosquitos (the imagines) leave their pupa-cases they are unable to pierce the human skin until the mouth parts have hardened, and this takes at least six hours. In England they can undoubtedly feed twenty-four hours after leaving the pupa-case. When feeding, both the sensory antennae and the tactile maxillary palps are thrust forward at right angles to the proboscis. They thus test the place where the two-lobed extremity of the labium will guide the battery of stylets into the substance they are feeding on. The female is much more voracious than the male, which, as we have mentioned above, cannot pierce the human integument, and has to be content with a vegetarian diet. Sometimes the effort even of the female mosquito to insert its

proboscis is fruitless, and we have watched a mosquito attempt four times to pierce the skin before it drew blood. If undisturbed during the meal the suctorial repast may last some two or three and a half minutes. So greedy at times is the mosquito that she resembles Baron Munchausen's horse after the adventure with the portcullis—what is flowing in at one end is flowing out at the other. In fact, as Dr. Johnson said of the boys at a school 'where discipline was maintained without recourse to corporal punishment,' 'But, sir, what they gain at one end they lose at the other!' After the process of biting, of sinking-in of the piercing needles, is complete, the proboscis is withdrawn, and to do this the mosquito braces herself on her legs and raises her body.

Another curious feature about the head of *Anopheles* is that it is pierced by two chitinous, symmetrical tunnels—tubes which are open at each end with trumpet-shaped orifices. The use of these is probably to act as a stay or strut to strengthen the chitinous exoskeleton of the head; but these queer galleries or tubes also to some extent act as attachments for muscles.

The antennae vary very much in the two sexes. In the female there are fifteen segments, each bearing a ring of hairs, but of small and disproportionate size, whereas in

the male the bushy character of the hairs is conspicuous even to the naked eye. In fact, it is the easiest criterion for judging the sex of the insect. At the base of the first joint of the male antenna is a deep cup-shaped structure packed with sense organs, and containing a large nerve ganglion. There are sixteen segments in the whole antenna, one more than in the female. The hairs are capable of movement, and as a rule are kept closed on the shaft of the antenna whilst not in use; when evening comes on they are spread out. There seems little doubt that these organs are auditory and help the male in searching for the female.

The beautiful transparent wings of the mosquito are beset with minute spikes, which serve to break up the light and to give rise to the many-coloured iridescence of the creature's wings. The posterior border of the wing bears rows of beautifully graded scales. These add much to the symmetry and beauty of the whole structure. Just behind it are two balancers or halteres—a name derived from the Greek word ἁλτῆρες, meaning a kind of dumb-bells which athletes used in the stadium when jumping. These so-called balancers project outwards and backwards from the body when the wings are in a position of flight.

A curious distinction between the *Culex*

and *Anopheles* is in regard to the position assumed by the insects when they rest. In *Anopheles* the proboscis and body are almost in one line, and the axis of the body is at an angle with the surface upon which it rests. *Culex*, on the other hand, has its proboscis at a slight angle with its body, and its body is almost parallel to the surface upon which it is perching. *Culex* has a much more hump-backed appearance than *Anopheles*, and its legs are considerably shorter and stouter. The insect generally rests upon four out of six legs; in the former case the hinder pair are held out and curved upwards. The hind legs not infrequently serve as a test for food. When feeding upon sweetened milk or fruit, the moment the hind leg touches the fluid or juice the insect will wheel round and at once begin to feed.

Anopheles maculipennis is very widely distributed, and it has been recorded from most parts of North America and Europe, and from many parts of Asia. Probably the species is much more widely distributed than we have any record, but individuals do not wander very far, of their own accord, from the breeding-places, though they may be dispersed by the wind. Cases are known where they have been blown as far as ten or even twenty miles; and in camping in Africa it is always well to keep to

the windward of a native village. They are also carried about by trains, motors, and steamers. They do not indulge in any such voluntary migratory flights as the locusts, although some such flights have been from time to time recorded, but these 'swarms' are probably due to a high wind catching a large number of mosquitos temporarily associated.

In a joint paper which Professor Nuttall and I wrote some years ago, we drew attention to a case in which mosquitos came aboard a ship some ten miles from land, and to another in which a Spanish barque from Rio was detained in the South Atlantic quarantine station of the United States. The vessel was so much infested with mosquitos that it was rendered nearly uninhabitable, and the United States quarantine officer reported that when the forecastle was opened after fumigation 'the mosquitos could be scooped up by hand.' The master of the barque was positive that there had been no mosquitos on board until the twenty-second day out. Howard quotes a letter from a General living in Texas in which he states he has 'twice seen flights of *Culicidae*,' but as the species and the genus are not given, much of the interest of the statement evaporates. Generals living in Texas are not invariably remarkable for meticulous accuracy in recondite scientific matters.

CHAPTER V

THE MOSQUITO (*Anopheles maculipennis*)

PART II

There in a wailful choir the small gnats mourn
Among the river sallows, borne aloft
Or sinking as the light wind lives or dies.
(JOHN KEATS, *To Autumn.*)

THE female imago hibernates. Finsch made observations and found it hibernating on the frozen Siberian tundras, beneath the moss and snow. Sterling found them in North America when the snow was melting, in great numbers, and he and his party were subsequently terribly bitten. There is no doubt that female imagines live throughout the winter, and they can be found in England, hibernating in cellars, old out-houses, chicken-houses, or disused farm buildings. These hibernating females disappear early in May, presumably having laid their eggs. Dr. Thayer of Baltimore describes these creatures, having found them on the roofs and walls of barns near New Orleans. Whether the male also hiber-

nates is doubtful. Grassi says he never found the male of *A. maculipennis* in the winter, only fertilised females. But as the warm weather sets in the female generally becomes active and bites, and the native American Indians consider these elderly and famished females give more annoyance than at any other stage in the life-cycle of either sex. In the warmer climate of Southern Italy they not infrequently hibernate in grottos and caves. At times they occur in such numbers that they can be swept up. After depositing their eggs the hibernating females probably die. This usually happens in May.

In the old days we used to collect gnats, keep them in a receptacle unprovided with any food, and when, after a couple of days, they died of starvation we wrote poems or essays on the 'Transitoriness of Life' and the 'Evanescence of Time.'

> The thin-winged gnats their transient time employ,
> Reeling through sunbeams in a dance of joy.
>
> (Mrs. Norton.)

Nowadays, we feed them. Bananas, sweetened milk, pineapple, or almost any other vegetable juice, is their diet, and in captivity they will live for weeks. At Cambridge in 1900 (July to August), Professor Nuttall was successful in keeping females alive

on a diet of bananas and water from two to eight weeks, but it was found essential to keep the atmosphere fairly moist and the food fresh. Grassi found that he could only keep *Anopheles* alive in his laboratory in Rome for a month.

Both *Anopheles* and *Culex*—at any rate, in captivity—lay their eggs early in the morning. Apparently the nature of the food has some effect upon their fertility, certain observers stating that when male and female are fed on vegetable food alone there is no fertilisation and no oviposition. A diet of blood evidently assists the female to lay her eggs, and perhaps to get them fertilised. One of our female *Anopheles* laid a batch of 146 eggs, and subsequently laid six more. But, as a rule, a fertilised female does not lay a second batch unless she receives a second meal of blood. The eggs are laid two or three days after the meal. There is also some evidence that a meal of blood is necessary if fertilisation is to be effected. As Austen says in *The Report of the Sierra Leone Expedition of the Liverpool School of Tropical Medicine* :—

The following law is likely to hold good for the *Culicidae* which feed on man—at least for the common species ; although these gnats can live indefinitely on fruit, the female requires a meal of blood both for fertilisation and for the development of the

ova. In other words, the insects need blood for the propagation of their species.

Undoubtedly, if mosquitos ever talk, they would talk like Mr. Waterbrook, Mrs. Henry Spiker—Hamlet's aunt—and the 'simpering fellow with weak legs' talked when David Copperfield dined with the first-named at Ely Place, Holborn. The burden of their song was: 'Give us blood.'

But a word of caution must be given here. Most of these deductions are based upon mosquitos in captivity; whether the same be true of them in natural conditions is not quite certain. If it be so it is difficult to see how these countless millions of gnats and mosquitos which dwell in the barren regions around the polar circle ever keep going.

It very frequently happens in the Animal Kingdom that females are much more numerous, as well as much larger, than the males.[1] As Kipling tells us: 'The female of the species is more deadly than the male,' but Professor Nuttall and I did not notice that this was the case with *Anopheles*.

There is some evidence that the male hatches out earlier than the female, and that in Southern

[1] This is a fact I have always tried to conceal from Mrs. Pankhurst; but, sooner or later, she is bound to find it out.

Europe there may be three or four generations in the course of the season: the first beginning in April and the fourth taking place between the middle of September and the middle of October. After that date no larvae were found. About four generations also occurred in the neighbourhood of Cambridge, according to observations of Professor Nuttall.

Kerschbaumer has calculated that if the average number of eggs laid by a female be 150, the number of the descendants by the fourth generation would amount to 31 millions. This readily accounts for the fact that in certain parts of the world they occur in perfectly enormous numbers, and if it be true that blood is essential for fertilisation and oviposition, very few of these potential mothers can breed. In nature they will feed on a great number of vegetable juices—melons, wild cherry-blossom, bananas, oranges, overripe mangoes; they suck the 'juices' of allied species of insects just when the imago is issuing from the pupa-case and before their integument is hardened, or they pierce the soft skin of the cicada, and occasionally attack the chrysalids of a butterfly. One of the most curious sources of food are very young trout. The adult insect attacks these *petits poissons filiformes*, 'literally sucking out their unsuspective little brains before they

could escape.' Grassi is doubtful whether the adult males feed at all. He states that he never found any food in their stomach, nor has he ever seen a male feed. But Professor Nuttall's experiments in Cambridge prove that males were seen repeatedly to feed, and to feed hungrily, on cherries, dried fruits, dates, and bananas.[1]

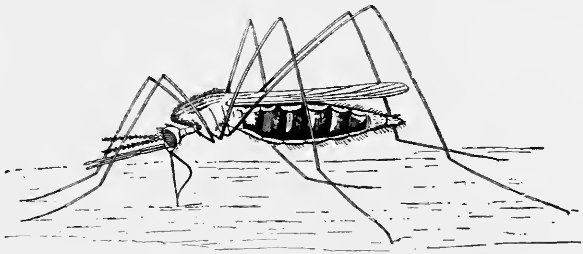

FIG. 16.—View of my arm being sucked by *Anopheles maculipennis* (female). (From Nuttall and Shipley.)

As mentioned before, the proboscis of the male is too weak to pierce the human integument, but Howard notes that it will suck up water, molasses, and beer; and Gray, at Santa Lucia, mentions that in that island *Culex* had developed a marked fondness for port wine. One particularly favourite food

[1] Owing to the recent restrictions on imported fruit imposed by the Government the food of these beautiful little insects will be further diminished. But what does our Government know or care about insects ?

is rose-buds covered with aphides—probably due to the sweetened secretion which these insects exude. The feeding is sometimes very ravenous, so that the insects become distended, the bright colour of blood, or coloured sap, readily shining through the joints of their chitinous armour.

The reaction to heat and cold is that common to many insects. During the winter the imagines become torpid, quiescent, and cease to worry one. With returning warmth they become lively again, and generally wake from their winter sleep in a state of considerable hunger. They are insects which prefer darkness to light, and during the day-time congregate in caverns and grottos, under the shade of trees and bushes, beneath bridges, in barns, and so on. As the sun sinks they emerge from their hiding-places and fly during the night.

Cambon, writing on *A. maculipennis* found in the Roman Campagna, says that imagines 'appear a few minutes after sunset and disappear a few minutes before sunrise.' We were able to confirm this at Cambridge. The insects retired into the shadiest parts of the boxes in which they were living until the time of sunset, when a loud buzzing was heard, and the insects promptly fed on the food which they had neglected during the

day. We kept our tame mosquitos in a huge gauze tent, and at night they invariably accumulated on the side which was illuminated by a lamp. Such mosquitos as were kept in a glass lamp-chimney, closed with gauze at each end, invariably flew towards the end which was held towards the light. People who are experienced with mosquitos sometimes keep the room in which they are sleeping dark and place a light in an adjoining room, leaving the door ajar, and thus lure them away. It seems a curious thing that, while these insects are repelled by the diffused light of the sun, they are attracted by the more concentrated light of a lamp or candle, but such is the psychology of *Anopheles*.

It is not perhaps solely the influence of light; it may be the influence of colour; for light is very rarely entirely colourless. In the many experiments carried on in Cambridge on the natural history of the mosquito, *A. maculipennis*, not the least interesting were those directed to ascertaining the insect's preference for colour. It had been noticed by many observers that they frequented dark-coloured areas rather than light: for instance, note how few mosquitos there are on the white collar of the gentleman in the Frontispiece compared with the number on his dark head and coat. Austen had pointed out that

in a room with a dark dado it was on the dado that the mosquitos were found rather than on the whitened walls above. Buchanan noted that the men when collecting *Anopheles* in an Indian hospital found they were to be most easily got by hanging up a dark coat or two upon the walls. A white coat they always avoided. The proverbial yellow dog of the West is much less bitten than the Newfoundland, and persons wearing dark socks and black shoes are more bitten than those who wear light ones. Natives, although they suffer less in health having acquired a certain immunity, are undoubtedly more bitten than the Europeans.

The experiments we carried on at Cambridge were as follows: In the large gauze cubical tent in which the mosquitos were bred and kept, a number of pasteboard boxes without lids, measuring 20 by 16 by 10 cm., were piled up. The boxes were lined with seventeen different coloured cloths, and were placed in rows one above another, and the order was changed each day, so that no question of height from the floor or better illumination entered into the problem. Counts were made of the inhabitants of each box on each of seventeen consecutive days, with the following results :—

Colour of box	Average number of mosquitos in each box.
Navy blue	108
Dark red	90
Brown (reddish)	81
Scarlet	59
Black	49
Slate grey	31
Dark green (olive)	24
Violet	18
Leaf green	17
Blue	14
Pearl grey	9
Pale green	4
Light blue (forget-me-not)	3
Ochre	2
White	2
Orange	1
Yellow	0
Total	512

It will be noted that about the level of the pearl grey there was a marked drop. Pale green and pale light blue, ochre, white, orange, and yellow—especially the last two colours—seem positively to repel the insect. Our khaki-clothed soldiers have other advantages than invisibility to the foe. This matter is worth pursuing farther, and it might be possible to design mosquito-traps lined with navy-blue; by periodically ex-

posing them to chloroform or benzine, or by sweeping out the contents, considerable numbers of mosquitos might be destroyed. A dark blue, sticky solution might be even more effective. After reading this chapter in the *British Medical Journal*, Mr. J. Cropper of Chepstow wrote to me as follows :—

> Seeing your article on Colour Selection by *Anopheles* reminds me that I found the dark navy-blue lining of my tent this summer (in Palestine) extremely attractive to mosquitos, almost entirely *Anopheles*; and when the sun got hot I always noticed an increase in their numbers, presumably as they came from the herbage and trees near by. No one ever slept in the tent, and I never found *Anopheles* bite in the day-time.

The best way of 'downing' mosquitos is to prevent the imago hatching, and this, as has been indicated, can be done by killing the larvae and the pupae, which is effected by brushing oil on the water in which they live. The petrol or crude mineral oil should be renewed from time to time as it evaporates. When once the mosquitos are hatched, every effort should be made to keep them outside dwelling-houses by means of wire screens, but if that be impracticable mosquito-nets should be used at nights. Professor Lefroy recommends one with sixteen to eighteen meshes 'to the inch.' They may be driven away from

a room by burning pyrethum powder in it, or vaporising cresol or carbolic acid, but of course this must only be done when a window is open, through which they can escape. As regards the human body, mosquitos may to some extent be kept away by smearing the skin with the various essential oils—such as eucalyptus oil or lemon-grass oil, &c. Mosquitos not infrequently bite through the socks, but wearing two pairs of socks instead of one pair, or inserting paper under the socks, often prevents their reaching the skin, as the proboscis is not long enough to penetrate two woollen socks, or strong enough to pierce the paper.

CHAPTER VI

THE MOSQUITO (*Anopheles maculipennis*)

Part III

The tiny-trumpeting gnat can break our dream
When sweetest. (Tennyson.)

It is now pretty well accepted that the auditory organs of the mosquito are situated in the antennae. Sixty years ago Johnston of Baltimore was investigating the hearing-apparatus of a gnat, and came to the conclusion that—

The animal may judge of the *intensity* or *distance* of the source of sound by the *quantity* of the impression; of the *pitch,* or *quality,* by the consonance of particular whorls of stiff hairs, according to their lengths; and of the *direction* in which the modulations travel, by the manner in which they strike upon the *antennae,* or may be made to meet either *antenna,* in consequence of an opposite movement of that part. That the male should be endowed with superior acuteness of the sense of hearing appears from the fact that he must seek the female for sexual union either in the dim twilight or in the dark night, when nothing save her sharp humming noise can serve him as a guide.

Johnston also notes that the male mosquito

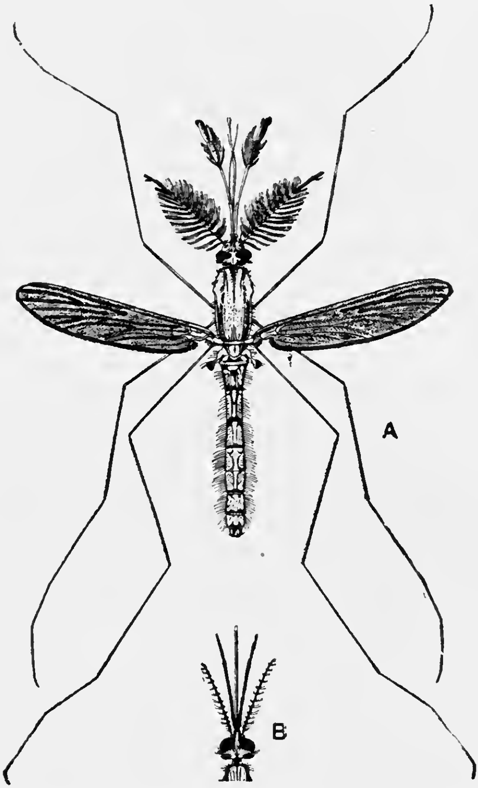

FIG. 17.—A, *Anopheles maculipennis*, male, showing large, feathered antennae. B, Head of female, showing antennae with feathering little developed. (From Nuttall and Shipley.)

is the more difficult to catch. The bushy, complicated antennae of the male show that of the two sexes, with the mosquito, as with

man, the male is primarily the hearer, the one who has to listen.

Another American, Mayer, twenty years later made some interesting experiments confirming the views held by Johnston. He managed to cement with shellac a species of *Culex* on to a glass slide, and, placing it beneath a low-powered microscope, watched the response of the antennae to tuning-forks of varying strengths. He found that under the influence of a fork producing 512 vibrations per second certain hairs of the antennae vigorously vibrated, whilst others were left unmoved. He measured the amplitudes of the vibrations of these hairs under the influence of the sound emitted by various tuning-forks. Different hairs were seen to vibrate to different notes. Mayer also observed that when the sound came from a direction in line with the long axis of the antennary hair vibrations ceased altogether. Hence he argued that the antennae could register the direction whence the sound came. Observing the antennae under the microscope, he confirmed the view that the vibrations ceased when the hairs pointed towards the source of sound, and on drawing a line in the direction in which the hair pointed, he found that it always cut within 5° of the position of the source of sound. He concludes :—

F 2

The song of the female vibrates the fibrillae of one of the antennae more forcibly than those of the other. The insect spreads the angle between his antennae, and thus, as I have observed, brings the fibrillae, situated within the angle formed by the antennae, in a direction approximately parallel to the axis of the body. The mosquito now turns his body in the direction of that antenna whose fibrils are most affected, and thus gives greater intensity to the vibrations of the fibrils of the other antenna. When he has thus brought the vibrations of the antennae to equality of intensity he has placed his body in the direction of the radiation of the sound, and he directs his flight accordingly, and from my experiments it would appear that he can thus guide himself to within 5° of the direction of the female.

There has always been some divergence of opinion as to how the buzzing sound to which the male so readily reacts is produced. Howard once thought that it was due to vibrations of certain chitinous processes in the large tracheae. Our experiments showed, however, that when the wing was cut off closer and closer to its origin the sound decreased in volume, but the note progressively rose. Unlike human beings, the male at all times emits a higher pitched note than the female, and in both sexes the note rises after feeding. 'The greater the meal, the higher the note.' This is, however, by no means confined to mosquitos. It is a matter which any one must have noticed

when assisting at a public dinner or when dining in a college hall.

Three unfed females gave a note of from 240 to 270 vibrations. One unfed female gave an abnormally low note of about 175 vibrations. Four other females, which were arranged in the order of the distension of the abdomen, after food gave notes corresponding to 264–281–297–317 vibrations; whereas three unfed males all gave exactly the same note corresponding to 880 vibrations. The explanation of the higher note of the males is probably that their wings are markedly narrower and shorter than those of the females.

Whilst working at *Anopheles* the late Mr. Edwin Wilson, the artist who was drawing our plates, observed at the base of the wing a structure which may possibly account for the tone which is so characteristic a feature of the buzzing. The articulation of the wing with the body is extremely complex. There seems to be a series of structures like minute knuckle-bones articulated with one another, and at the outer end of the series are two ribbed rods which may play some part in the production of the overtones. One is a chitinous bar with some fourteen or fifteen well-marked ridges. In certain circumstances we consider that the other toothed rod can rasp across the ridges of the bar below it. As the wing is

raised and lowered it seems probable that the slightly movable rod would be drawn across the ridged bar.

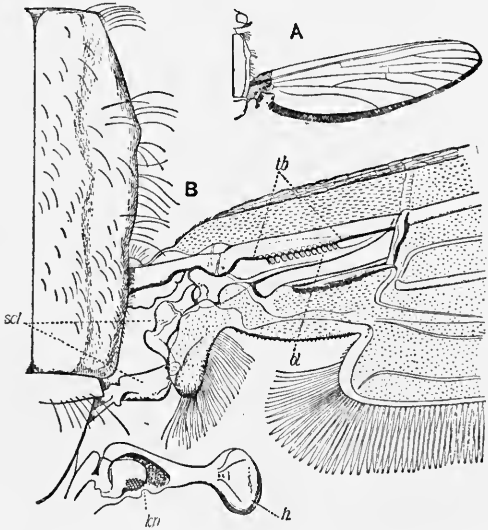

FIG. 18.—B, Right half of thorax of *Anopheles maculipennis*, Meig, with base of right wing and right halter, magnified about 30. A, The same magnified about 5, to show the area which bears the stridulator. *tb*, The teeth which rasp on the ridges borne by *bl*; *kn*, papillae on knob; *h*, distal end of halter; *scl*, chitinous thickenings. (From Shipley and Wilson.)

We have mentioned above that the mosquito's note increased in pitch as the wings were shortened until a very short stump was left. As long as these stumps were left a note was heard, and these stumps would undoubtedly include the apparatus just

described, for it is next and nighest the insertion of the wing into the body. But Dr. Nuttall found that when this short stump was removed all perceptible sound ceased, which is certainly an argument in favour of these rods and bars playing some part in the production of the buzzing, and in opposition to the view of Howard and others that the buzzing is caused by certain chitinous structures in the tracheae.

M. J. Perez[1] has carefully gone into the question of the production of sound in the Diptera. He claims to have shown experimentally that the stigmata take no part in the production of sound. 'Les causes du bourdonnement résident certainement dans les ailes.' He, too, points out that if the wings are cut short the notes become more acute, until the *timbre* resembles that of certain interruptors which break and make an electric conductor. This sound we should attribute to the stridulator described above. M. Perez definitely states that both in the Diptera and in the Hymenoptera the buzzing is due to two causes: 'L'une, les vibrations dont l'articulation de l'aile est le siége et qui constituent le vrai bourdonnement; l'autre, le frottement des ailes contre l'air, effet qui modifie plus ou moins le premier.' The apparatus we

[1] *Compt. Rend. Acad. Paris* (1878), lxxxvii, p. 378.

have described is, we believe, the mechanism by means of which the first vibrations are produced.

In the same periodical M. Jousset de Bellesme [1] confirms the statement that both Dipterous and Hymenopterous insects emit two sounds—one deep and one acute, and states that the latter is usually the octave of the former. It is this double note which gives rise to the peculiar buzzing associated with these two orders of insects. M. de Bellesme, like M. Perez, discards the view that acute sounds are due to any action of the issuing air in the stigmata, and attributes it to the vibrations of the pieces of the thorax which support the wing, and which are moved by the muscles of flight. It is usually stated that these muscles are not inserted into the wing, but into the sides of the thorax, to which the wing is so attached that when the lateral walls of this part of the body are deformed by the action of the muscles the wings move up and down. But whether this be the case or not, it is clear that the vibrations of the sides of the thorax caused by the muscles of flight—and causing the vibrations of the wing—will synchronise in number with these wing vibrations, and will give forth the same note. The existence of the higher note

[1] *Compt. Rend. Acad. Paris* (1878), lxxxvii, p. 535.

—'usually the octave' of the one produced by the wing vibrations—is unexplained by this view. It is, however, easily explicable if such a stridulating organ as we have described at the base of the wing in *Anopheles maculipennis* be found in other Diptera and in Hymenopterous insects.

In our paper Mr. Wilson and I thought it well to figure the upper surface of the halter as seen under a high magnification. The drawing showed the hinge on which the halter quivers—and certain basal papillae, as Weinland [1] calls them. There is little doubt that the main function of the halteres is that of balancing and orientating the insect. They may, however, have a secondary function; in some flies they are known to vibrate with extreme rapidity. It is just possible that in these rapid vibrations the papillae of the concave surface rubbing against those of the convex basal plate may produce a note. As long ago as 1764 von Gleichen-Russworm [2] observed that when the halteres of the common house-fly are removed the volume of the buzzing diminished. This, however, in all probability is due to the diminished activity of the wings. On the other hand, Professor J. Stanley Gardiner informs us that he has

[1] *Zeit. f. wissensch. Zool.* (1891), li, p. 55.

[2] *Geschichte der gemeinen Stubenfliege.* Nuremberg, 1764.

noticed that mosquitos still continue to give forth a faint note even when their wings are quite at rest, and this note may possibly be caused by the halteres.

The part which sound plays in the life of the mosquito has not been very fully recognised. Grassi says that people who are talking are more liable to be bitten by *Anopheles* than people who are silent—and quite properly, we think; people are apt to talk too much, especially in trains. Joly observes in Madagascar that mosquitos are attracted by music. When he played a stringed instrument the quiescent mosquitos in his room began to fly about, and if the windows were open mosquitos were attracted from the outside into his room, and he notes that mosquitos are attracted by musicians when at work, or should we say—at play?

Two curious instances—one recorded by Howard and the other printed in a letter to *The Times*—of the attraction that electric buzzings have on these insects may be given. Mr. A. de P. Weaver, an electrical engineer, of Jackson, Miss., U.S.A., records that, when engaged in some experiments in harmonic telegraphy, he observed that when the note was raised to a certain number of vibrations per second, all the mosquitos—not only in the room, but from the outside—would congregate

near the apparatus, and were, in fact, precipitated from the air with a quite extraordinary force, hurling their frail bodies against the buzzing machinery. This machinery formed, in conjunction with sticky fly-paper, an excellent means of capturing them. Mr. Weaver then devised a means of electrocuting the pests. He used a section of unpainted wire screen mounted on a board with pins driven through the meshes, the heads of the pins being flush with the surface of the screen. The bodies of the pins were then electrically connected together, the whole forming one electrode of the secondary coil of an induction coil, whilst the wire screen formed the other electrode. An alternating current of high potential was passed, and when the note was sounded the insects precipitated themselves to their doom, being electrocuted the moment they touched the apparatus.

A somewhat similar story is told by Sir Hiram Maxim in *The Times* of October 29, 1901. One of the lamps in an installation which was put up in Saratoga Springs, New York, hummed in an agreeable manner, and he noticed that night after night this lamp was covered with small insects. On closer examination he found that they were all mosquitos, and all males.

CHAPTER VII

THE MOSQUITO (*Anopheles maculipennis*)

Part IV

Gnats are unnoted wheresoe'er they fly,
But eagles gazed upon with every eye.
(Shakespeare, *Rape of Lucrece.*)

The eggs of the mosquito are deposited in fresh water, and at first they are white, but they very rapidly darken until they assume a polished black appearance. Each egg is 0·72 mm. in length, and its greatest breadth, which is somewhere about its middle, is 0·16 mm. The egg is boat-shaped, and one end, as is usual in boats, is slightly deeper and fuller than the other. The under surface is fluted, and is marked by a minute network. The upper surface has a coarser reticulation which divides the surface into nearly equal hexagonal areas. The rim of the 'boat' is thickened, and these thickenings are regularly ribbed; they extend over above the median third of the egg, and recall the rounded float which runs along the edge of a life-boat:

and indeed they serve the same purpose, for they are composed of air-cells, and their function is to keep the boat-shaped eggs right side upward. Soon after the egg has been laid it is of a greyish-black colour, but after a certain amount of attrition an outer membrane splits off—the membrane which has given the egg its reticulated appearance. This membrane scales off in fragments, and is of a grey colour. The egg beneath it is glistening black—as shiny and as black as patent leather.

One curious fact that Professor Nuttall and I noticed in the life-history of the egg is that when it is drawn by capillary forces a little way out of the water on to the leaf of a water-plant or some other half-submerged object, the blunt end always points downwards. Now the blunt end is the head end, and thus, should hatching take place whilst the egg is suspended half in the water and half in the air, the larva will emerge into its proper element and not into the atmosphere.

Like other objects floating on the surface, the mosquito-egg slightly indents the surface. The number of eggs seems to vary. According to Grassi, each female deposits about one hundred eggs, whilst Howard puts the number as varying from forty to one hundred. We, however, found in captivity the female

laid about one hundred and fifty. According

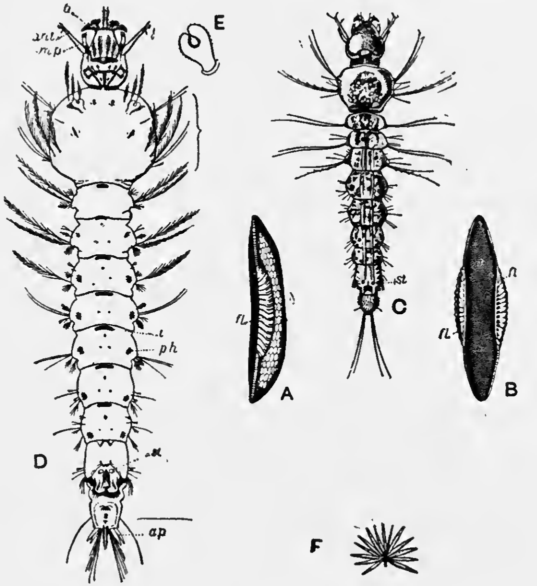

FIG. 19.—Larva and eggs of *Anopheles maculipennis*. A, Egg seen from the side, × about 20; *fl*, the float. B, Egg seen from the upper surface, × about 20; *fl*, ridge of air-chambers, which acts as a float. C, Very young larval stage, × about 20; *st*, stigma. D, Fully grown larva, × about 20; *b*, brush *ant*, antenna; *mp*, palp of maxilla; *st*, stigma; *t*, tergum; *ap*, anal papillae. E, Flabellum or flap, which overhangs the base of certain thoracic hairs. F,. A palmate hair, highly magnified. (From Nuttall and Shipley.)

to Grassi, the eggs of *A. maculipennis* lie side by side like the bridges of boats which span the Rhine, whilst those of *A. bifurcatus* arrange themselves with their ends in

contact, forming starlike patterns. Unlike the eggs of the gnat (*Culex*), the eggs of *Anopheles* do not adhere together, and the result is they are very readily scattered by the wind. But in sheltered places, like a laboratory aquarium, if undisturbed, the Italian Professor found that they tended to congregate together, as indeed do most minute objects floating on the surface of the water. Our observations did not entirely confirm those of Grassi. In Cambridge, at any rate, we found the eggs in our aquaria always scattered. Very frequently empty egg-shells were met with, but they too were scattered. As a rule, in nature, the ova are deposited in water rich with algae or other vegetable life, and they are more frequently in shallow than in deep water, the temperature of shallow water being naturally somewhat higher.

On the second or third day after oviposition (and this depends upon the temperature), the young larva leaves the egg and begins to swim in the water. The egg hatches by the detachment of a cap-like portion of the anterior end of the egg-shell. There is no visible ring indicating the limits of this operculum, but the cap is usually more or less of the same size. Opinions differ as to how far desiccation interferes with development of the larva in the egg-shell. They do

not seem to be able to stand more than forty-eight hours of drought. There is no evidence that they can survive throughout the winter period. Everything that we know indicates that the egg must pass this period within the mother's body, and that they only attain maturity in early spring, when the weather becomes warmer.

The larva of the mosquito is one of the most fascinating objects one can watch under the microscope. It is very complex, and consists of the usual arthropod regions of (1) the head, (2) the thorax, and (3) the abdomen.

Without going into the question of how many typical somites make up the head, we must state that the thorax has the typical number of three, much fused together, and the abdomen nine. The first seven of these are very much alike; the eighth, however, bears the large stigmata or orifices of the breathing system, and the ninth a number of beautifully arranged hairs, by means of which the larva to a great extent steers itself. The head resembles two-thirds of a sphere, and is covered with a complete and clearly defined brown, chitinous case. The eyes are lateral, and on each side we have both a simple and a compound eye. In front of each eye is a little protuberance, which

carries the antenna, and between these two eminences a band of pigment runs across the head, from which six symmetrically placed immovable feathered hairs project, wreathing

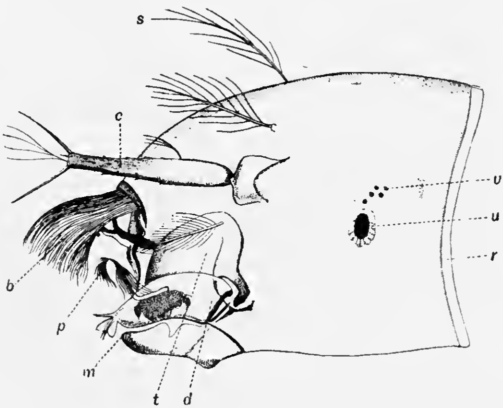

Fig. 20.—Side view of head of a fully grown larva of *Anopheles maculipennis*. *b*, Brush; *c*, antenna; *d*, palp of maxilla; *m*, hooked hairs at edge of maxilla; *p*, median tuft of hairs; *r*, thickened rim of chitinous covering to head; *s*, large, feathered hairs which overhang head; *t*, mandible; *u*, larval eye; *v*, eye of adult, forming above and behind *u*. (From Nuttall and Shipley.)

the head, as it were, with a halo. There are many other hairs on the head, whose number and shape are of great systematic importance. The anterior edge of the head carries on each side of its under surface a conspicuous brush, very like a shaving-brush, the constituent hairs of which are arranged in a spiral, and

it is these brushes which sweep the food into the mouth of the young and voracious larva. The base of this brush is so arranged

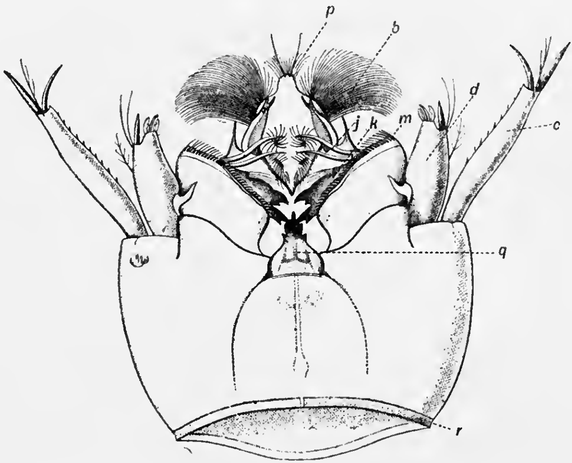

FIG. 21.—Ventral view of head of a fully grown larva of *Anopheles maculipennis*. *b*, Brush; *c*, antenna; *d*, palp of maxilla; *j*, stout hairs of mandible, which arrange the brush; *k*, teeth of mandible; *m*, hooked hairs at edge of maxilla; *p*, median tuft of hairs; *q*, the 'underlip' of Meinert, or metastoma; *r*, thickened rim which passes into the soft tissues of the neck. (From Nuttall and Shipley.)

that when depressed and bent towards the mouth the two brushes approximate, but each brush can move independently and often does so: one may be depressed towards the mouth, whilst the other remains erect.

The larva passes its life hanging on to the under surface of the surface-film of the water, its dorsal surface being uppermost. In fact, as Sidney Smith pointed out about

the sloth, 'it passes its life in a state of suspense, like a young curate distantly related to a bishop.' But, since these larvae feed on any kind of organic débris that floats up to the top and is there arrested by the surface-film, it is obviously important that the brushes which sweep together these organic particles and carry them to the mouth should be next the surface, and to effect this the head must rotate through an angle of 180°; and the head does in fact turn upside-down on the neck so sharply and accurately that, as it comes into position, you almost think, as you are watching it, that you hear a click, just as you do when you rotate the diaphragm of a microscope.

The mouth parts now begin to vibrate upwards and forwards, and the brushes are bent downwards, backwards, and inwards. Round the mouth is a small space, the walls of which are completed by the mandibles, and into this space the brushes are suddenly bent back, at the same time the mandibles and maxillae move forward to meet them. This movement may take place as many as 180 times a minute, and it produces a current converging in concentric curves towards the above-mentioned chamber. The water filters out between the sides, and any particle of food is retained by the hairs or by the mouth appendages; from time to time the mandibles

are brought together, and their stiff bristles are run through the brushes as one's fingers run through a beard;[1] at other times the brushes disappear far into the mouth, and then are slowly withdrawn, passing through the comb-like bristles on the mandibles. The brushes are frequently swallowed, and are withdrawn in little jerks, so that the maxillae have every opportunity of combing any nutritive particles out of them. The whole operation is a most fascinating one to watch.

As far as one can judge, the currents set in motion by the action of all these forces extend in an area equal to twice the length of the larva, or even more. The currents are in the plane just below the surface-film, and any organic matter lighter than water is swept towards the mouth. In fact the larva sweeps the lower side of the surface-film of the pond or puddle just as a careful housemaid might sweep spiders and flies off a ceiling with a hand-brush.

The principal food-supply of the larva consists of the spores of fresh-water algae, diatoms, particles of *Spirogyra*, and any other organisms which do not penetrate the surface-film. Occasionally the larvae devour the decaying leaves of duck-weed (*Lemna*), and sometimes they attack their dead fellows.

Grassi found the intestine of the larva

[1] If you have a beard.

to contain protozoa, unicellular algae, and other organic detritus. In course of time

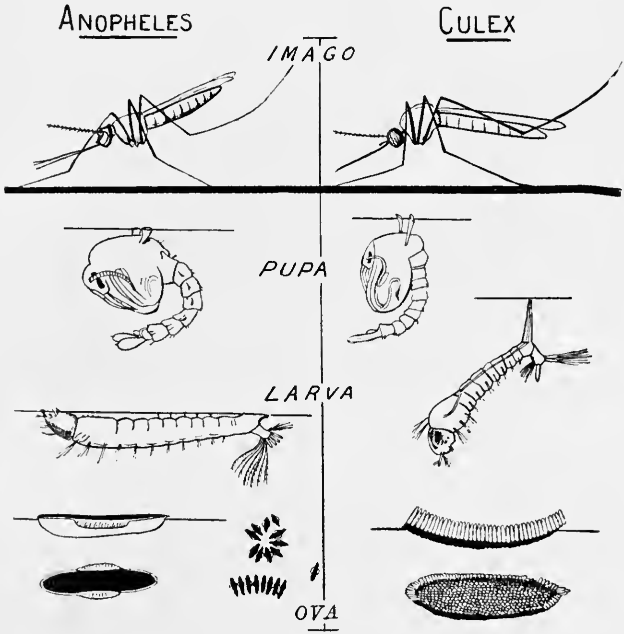

Fig. 22.—A comparison between the various stages in the life-history of the mosquito (*Anopheles*), on the left, and the gnat (*Culex*), on the right.

some object too big for the larva to swallow is brought to its mouth by the currents, but after a very short struggle this is rejected. The minuter particles accumulate in the chamber for a certain time, and then are swallowed by a gulp-like motion and thus pass into the oesophagus.

CHAPTER VIII

THE MOSQUITO (*Anopheles maculipennis*)

Part V

Amongst aquatic larvae, the most beautiful and delicate are those of numerous species of gnat.—(Goring and Pritchard's *Micrographia*, 1837.)

In the young larva of *Anopheles* the head is broader and deeper than the thorax, but in the older larvae the segments that succeed the head have at least twice its diameter. It is a characteristic of true flies, or Diptera, that the thorax should not exhibit that separation into three divisions which is so usual is the less specialised insects—such as the cockroach and this is peculiarly true of the larva of the mosquito—at any rate, so far as its external structure goes. The abdomen of the larva consists of nine free segments; the third, fourth, fifth, sixth, and seventh of these bear palmate hairs on the dorsal or upper surface, something like hands with fourteen 'fingers' spread out. These hairs adhere to the under layer of the

surface-film of the water, and help to maintain the animal in a horizontal position just below that film. When the larva relaxes its hold and sinks into the water, it not infrequently carries with it air-bubbles enclosed by these fourteen ‘fingers.’

The eighth abdominal segment bears the stigmata or the openings of the respiratory apparatus, and the ninth segment has abandoned the flattened and square cross-section of its predecessors, and is cylindrical and tapering. The posterior end of the body is cut off sharply. Round the posterior opening of the alimentary canal are four white, soft papillae, which are well supplied with tracheae and are capable of contracting and expanding. Above these are four very prominent hairs, two median and two lateral, and ventrally to the ninth abdominal segment is a fan-shaped arrangement of hairs springing from two pieces of very complicated structures. These hairs seem to act to some extent as a rudder, and they probably serve as an accessory organ of locomotion. Possibly they have also a sensory or tactile function, and act, as so many posterior filaments do in insects, as antennae ‘from behind.’

We have referred above to the respiratory openings, and, indeed, these are the key to the whole situation. Close these openings—

as they can be closed by floating petrol or other oil on the surface of the water—and 'the trick is done.' The larvae and the pupae can no longer breathe, and there is thus no imago to "carry on." In *Culex* (the gnat), these respiratory orifices are borne on a long tube directing dorsalwards—a tube which is larger and longer than a segment of the body, and whose presence gives the larva the appearance of a Y with slightly unequal limbs. These breathing-openings are of the greatest complexity, but the outstanding fact is that these stigmata pierce through the watery film and put the respiratory system of the larva into communication with the atmosphere of the whole cosmos. If anything frightens the larva, certain side-pieces and flaps fold suddenly backwards and over the stigmata, the connexion through the surface-film is broken, and the little larva, like a German submarine when it sights an English battleship, darts below, frequently carrying with it the drop of air attached to the rim of the respiratory recess which surrounds the openings of the two stigmata.

Not infrequently the larva ceases to lie parallel to the surface of the water, its palmate hairs are put out of action, and then its body hangs down into the water, but it still maintains its respiratory connexion with

the outer air through these breathing - pores. From time to time the hairs mentioned above are brushed over by the mouth parts and cleaned of any débris.

The larvae, when they leave the surface-film sink by their own weight; but they not infrequently swim actively downwards, their swimming action being very like that of an eel. When returning to the surface they are entirely dependent upon their powers of swimming, being slightly heavier than water. When the tail reaches the surface-film the larvae are at once arrested, and immediately cease their swimming-movements. They invariably move tail forwards, and the hairs which we have mentioned above at the posterior end of the body undoubtedly act as 'buffers' or 'fenders.' As a rule, when they are above, they are actively engaged in feeding; but at the bottom they lay inert, as though feigning to be dead. Kept in a glass beaker they are apt to lie with their respiratory apparatus attached to the concave film, which capillary attraction draws up on the surface of the glass. Their heads then point towards the surface of the beaker. If forcibly kept below—say, by submerging them under a watch-glass—they are frequently enabled to breathe by attaching the openings of their respiratory apparatus to an air-bubble.

The general colour of the larva is a mottled brown, darkening where the chitin thickens. The older larvae are to some extent green, possibly due to their food; but this green colour is not by any means confined to the alimentary tract. After moulting, the issuing larva is a uniform light lavender colour, which, however, very soon darkens.

A strong wind passing over a pool where *Anopheles* eggs, larvae, or pupae are floating, will gradually pile them all up on the side towards which it is blowing. The *Anopheles* larvae undoubtedly are braver than those of the *Culex*—that is to say, a disturbance which will send all the *Culex* larvae scurrying to the bottom will leave the *Anopheles* larvae unmoved.

When first hatched the larvae measure somewhere about 0·7 mm. to 0·95 mm., but when ready to pupate they have attained the length of 7 mm. The rate of development is greatly influenced by the temperature, and a few cold days will markedly retard the larval growth. In warm sunny weather, larvae will pupate between the second and third week, but larvae taken in August (if the autumn be cold) do not attain their full growth until November. The young larvae undoubtedly die in considerable numbers, and the act of pupating is also attended with

certain and varying dangers. Out of 834 larvae and pupae caught in Cambridgeshire, 636 were small larvae, measuring less than 4 mm.; 181 were large larvae, measuring up to 7 mm. But only 17 pupae were taken. There are other facts which show that the larvae under natural conditions succumb in very considerable numbers.

When the larva is about to turn into a pupa it comes to rest, and now the thoracic regions are more swollen than ever. Soon a dorsal slit appears along the larval cuticle and the pupa slowly, but gradually, emerges through this slit and leaves the larval chitinous cuticle behind it. On first emerging, the pupa measures about 6·5 mm., the head and thorax making up one-third of this. During the last larval stage many of the pupal organs have been re-forming and are more or less visible through the cuticle. The mouth parts and limbs of the third stage—the future imago—show no relation to those of the

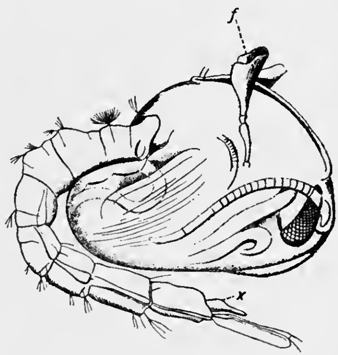

Fig. 23.—Side view of late pupal stage of *Anopheles maculipennis*. *f*, The stigma opening at end of trumpet-like projections. (From Nuttall and Shipley.)

larva. They are there enclosed in their respective sheaths, but these are quite independent of the larval 'appendages.' The respiratory trumpets, which, as in the larva, pierce the surface-film, are ready to act as breathing-organs. Whereas the larvae breathe through two stigmata at the posterior end of the abdomen, the pupae breathe through two respiratory trumpets issuing from the anterior dorsal surface, and it is these trumpets, together with certain palmate hairs, which support the pupae in the right position and put the respiratory organs at this stage into communication with the outer atmosphere. During the pupa stage *Anopheles*, like the pupa of other insects, takes no food.

The pupa is something like a tadpole, with its tail bent under its body and flapping up and down, instead of from side to side. The whole pupa is enclosed in a thin semi-transparent membrane, through which the organs of the adult can readily be seen. As it grows older its colour darkens. Until about the time when it will give rise to the fly, the pupa floats quietly at the surface, breathing through its respiratory trumpets. When disturbed it shows considerable activity, and it is by no means always easy to capture by means of a pipette. At the least sign of danger it darts below with a series of inter-

mittent strokes and rests at the bottom of the water. Its own buoyancy brings it back to the surface, as, unlike the larva, it is lighter than water. Not only has it a certain amount of air in its tracheae, but there is a reservoir of air at the posterior end of the thorax which acts as a very efficient float. When

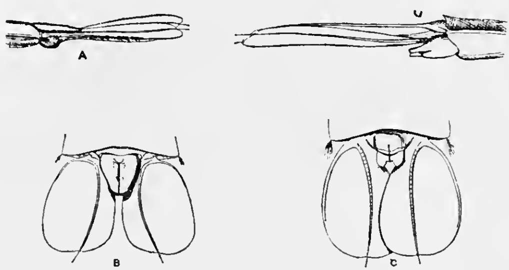

FIG. 24.—A, Side view, B, ventral view, of the pupa of a male *Anopheles maculipennis*; C and D, the same views of the female pupa.

retreating below the surface the respiratory trumpets usually carry down with them two minute air-bubbles.

The sex of the pupa can be determined by the lobes at the posterior end of the tail: A and B (Fig. 24) representing the male, and C and D the corresponding parts of the female. The duration of the pupal life is generally three to four days, but conditions of temperature and the state of the natural surroundings exert considerable influence upon the rate

of development. Howard has pointed out that the addition of creosote or creosote-oil to the water in which the larvae are living hastens the metamorphosis into pupae, and the pupa stage is passed through in as short a time as fifteen hours instead of the normal forty-eight hours of the warm waters of the Southern States in America. It has also been observed that showery weather hastens the rate of development.

When the adult mosquito is about to emerge, a certain amount of air is secreted under the chitinous casing of the pupa. A fine streak containing air appears along the back, extending between the respiratory trumpets and the base of the head. This central streak gradually passes backwards until it reaches the seventh abdominal segment, and then suddenly the pupa extends its abdomen so that it floats parallel to the surface of the water instead of being under the rest of the pupa's body. The chitinous integument now splits along the median dorsal line, and through the slit thus made the thorax of the adult mosquito now protrudes. By gradually pressing its abdomen against the pupa-case, the body of the perfect insect is slowly but gradually raised above the surface of the water. The head is pulled backwards and upwards, and millimetre by millimetre the mouth parts, the

palps, and antennae are withdrawn, and at first remain bent backwards beneath the body of the insect. Gradually the bases of the wings and the abdomen emerge, and soon the wings are freed and immediately flatten out and begin to harden. The legs and the tip of the abdomen alone now remain to be dealt with. At this stage the insect projects far beyond the anterior end of the pupa encasement, and somewhat resembles an exaggerated figure-head on a ship. The pupa-case is still filled with air, and acts as a float to support the emerging insect. At last the front legs are being freed, the second and third pair of legs soon follow, and now the insect is standing on the surface of the water raised on its tarsal joints, the tip of the abdomen being the last part to free itself from the pupa-case.

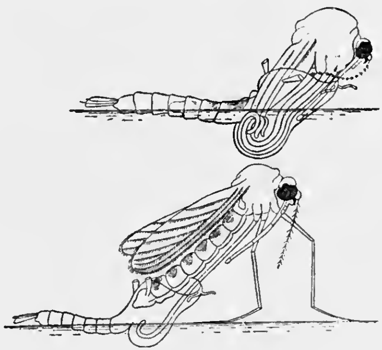

FIG. 25.—Imago of a mosquito extracting itself from the pupa-case, which floats on the surface of the water. Magnified. (From Guiart.)

The exit of the fly is naturally a very critical pediod in its life-history, and in many cases it is fatal. The freeing process takes

between five and ten minutes. When undisturbed the emergent fly rests for a time until its wings and limbs are sufficiently hardened to enable it to fly, or at least to walk about. Sometimes the mosquito takes its first flight straight from the pupa-case; at other times it rests awhile before taking to the air. The young imago is pale in colour, the thorax being brown and the abdomen transparent, with a greenish tinge. At first the abdomen is much longer than it is later, for, almost immediately after the mosquito's exit from the pupa-case its abdomen begins to contract, and from its hinder end four or five drops of a glistening, greenish-white fluid are exuded.

The newly born imagines generally take to flight between five and ten minutes after they have emerged, and they at once begin to darken in colour, and in two hours assume the normal dusky colour of the adult. If anything hinders the insect from properly extending its limbs immediately on issuing from the pupa-case, the parts harden and remain distorted throughout life.

Anyone who has spent a day or two in Lille or Bruges, or other towns in Picardy and in Southern Belgium, will understand why, as my Uncle Toby has it, 'Our army

swore terribly in Flanders.' The incessant and tireless biting of mosquitos would make any army swear, even though they were ignorant—as my Uncle Toby's army certainly was ignorant—that the gnats, as they called them, conveyed tertian and quartan ague. In Europe the trouble is a summer or early autumn trouble; but our troops are fighting in many tropical and sub-tropical countries, where the mosquitos — like the poor — are always with them.

That the plague can now be checked is shown by the making of the Panama Canal; and that this check is due to British science is shown by the work on the life-history of the malarial organism, first investigated by Sir Ronald Ross, and later, as regards the human parasites, by certain Italian savants. It is also due to the public health services of one or two British medical officers of health in the East. *Their* methods have been applied and improved by those responsible for the elusive channel which now at times separates North from South America.

We have seen that the larva and the pupa hang on to the surface-film of the water by means of certain suspensory hairs, and by the openings of their breathing-apparatus. Anything which prevents the breathing-tubes reaching the air ensures the death of the

larva and pupa, and then there is no issuing adult—hence the use of paraffin on the pools or breeding-places. It, or any other oily fluid, spreads as a thin layer over the surface of the pools and puddles and clogs the respiratory-pores and the larvae or pupae die of suffocation.

In Ismailia the disease has been reduced to an amazing extent, and remarkable results have followed the use of these preventive measures at Port Swettenham in the Federated Malay States. Within two months of the opening of the port in 1902, 41 out of 49 of the Government quarters were infected, and 118 out of 196 Government servants were ill. Now, after filling up all pools and cleaning the jungle, no single officer has suffered from malaria since July 1904, and the number of cases amongst the children fell from 34·8 to 0·77 per cent. The only melancholy feature about this wonderful alleviation of suffering, due to the untiring efforts of the district surgeon, Dr. Malcolm Watson, is that his fees for attending malarial cases dropped to zero.

Thus, even ten years ago, a considerable degree of success had attended the efforts of the sanitary authorities—largely at the instigation of Sir Ronald Ross—all over the world, to diminish the mosquito-plague. It

is, of course, equally important to try to destroy the parasite in man by means of quinine. This is, however, a matter of great difficulty. In Africa and in the East nearly all native children are infected with malaria, though they suffer little, and gradually acquire a high degree of immunity. Still, they are always a source of infection; and soldiers stationed in malarious districts should always place their dwellings to the windward of the native settlements.

Knowing the cause, we can now guard against malaria; mosquito-nets and wire-protected windows and doors are a sufficient check on the access of *Anopheles* to man. If the mosquito and man could only be kept permanently apart, we might hope for the disappearance of the parasite from our fauna. In relieving man from this world-wide pest, all genuine lovers of animals will rejoice that we are also relieving the far more serious lesions of one of the most delicate and beautiful insects that we know.

It has always been a source of surprise to me that the great resources and the very evident enthusiasm of the anti-vivisection societies have not been turned in this direction. In the malarial parasite, we have a most potent vivisector of the entrails of one of the most charming and graceful of creatures, whose

poetry of movement is hardly approached and never equalled by the ladies of the front row of the ballet. A little help, a very little help, would free these fascinating flies from a form of trouble far worse than that the human alternative host suffers. Yet, as far as I know, these societies and the societies for the prevention of cruelty to animals have declined to help in any way, and have knowingly allowed thousands of millions of animals to perish annually by a most painful death, and have never stretched out a helping hand to the fairy-like and fascinating mosquito.

CHAPTER IX

THE YELLOW-FEVER MOSQUITO (*Stegomyia calopus*)

> . . . et nova febrium
> Terris incubuit cohors.
>
> (Horace.)

Like other branches of human activity disease has its romantic and its unromantic side. Nobody can regard mumps or measles as romantic. On the other hand, yellow fever calls up all the romance of slave-trading, pirates and the Spanish Main, buccaneers, maroonings and other grisly horrors, whose sole redeeming feature was a touch of romance. Lovers of pirate stories—and who are not ?—will always remember their graphic description of Yellow Jack in the West Indies.

We have probably always had disease with us since the creation of the world—that act of '*impardonnable imprudence*,' as Anatole France calls it; but the first description of yellow fever only dates back to 1647, when an outbreak occurred in the Barbados. Then, as now, it devastated the shipping of the port,

and was soon introduced by ships into St. Christopher and, later, into Guadeloupe. The following year it was in Cuba, and in 1655 in Jamaica, and it gradually spread throughout the whole of the West Indies until a century or more later it reached the Island of St. Thomas.

One of the peculiarities of the disease is that it frequently disappears from a given locality for long periods of time. For instance, it was absent in Barbados after the first outbreak until 1690, and when it recurred it was at first not recognised as being the same disease which devastated the islands forty-three years before. In the eighteenth century there was another break of fifty-four years, and similar breaks can be recorded in most of the West Indian islands.

Besides the West Indies, it is at present endemic in Brazil and on the west coast of Africa, and is common in Mexico. Whether the disease arose primarily in Africa and is part of the toll the American continent has had to pay for the slave-trade, or whether it was brought to the west coast of Africa from the other side of the Atlantic, is not certain. It apparently appeared as a regular disease in Brazil in the year 1849, and from that time onwards, with the exception of one year, has been a permanent trouble at Rio. From time

to time the disease has been carried to neighbouring parts of America, especially to the Gulf, Central America, and the northern coast of South America. It has been introduced more than once into Monte Video and Buenos Ayres, and has even penetrated up the Parana as far as Asunçion. Every few years it extends into the Southern States and has even reached Philadelphia and Boston. With the exception of an outbreak in Leghorn in 1804, European epidemics have been confined to Portugal, Spain, and the Balearic Islands.

It will have been noticed that most of these outbreaks occur on the coast and then pass up the rivers. It is thus most probable that the disease is one which is brought mainly by ships. It is obviously a disease which must be guarded against by our troops fighting near the coast in West Africa, as well as such troops as are left in the West Indies. But, above all, it must be guarded against in relation to our shipping fleet and our Navy, operating off the South American coasts. The danger, now the Panama Canal is open, of introducing the disease from America to Asia is a danger that should carefully be considered.

Yellow fever is a disease which requires a winter temperature of at least 68° F., for it is a mosquito-borne disease, and the yellow-fever mosquito flourishes best at about this tempera-

ture. It can be introduced into a new locality by the arrival of an infected mosquito, or by the arrival of an infected human being. In the former case the disease breaks out within a few days; in the latter at least ten or twelve days elapse before new cases arise, for, as we

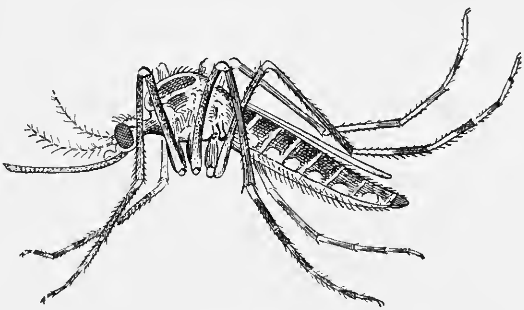

FIG. 26.—*Stegomyia fasciata.* Female, lateral view (magnified.) Note hump-backed outline, and also the position of the posterior pair of legs.

shall see later, the organism, whatever it is, that causes the fever is not capable of passing from the mosquito until it has been in its body for ten or twelve days.

Thirty-six years ago Finlay of Havana suggested that the virus of yellow fever was inoculated by mosquitos; but it was not until the publication of the discoveries by Sir Ronald Ross and others, that malaria is transferred by *Anopheles*, that a thorough investigation of yellow fever was made. In the last

year of the last century an American Commission, consisting of Drs. Walter Reed, Carroll, Agramonte, and Lazear, investigated the whole subject, and, taking extraordinary risks, were able to prove that the infection was not conveyed by contact or through the air, or from bedding or clothes soiled by the dejecta of yellow-fever patients, but by a mosquito of the genus *Stegomyia.* Whatever the virus is, it is invisible, even under the highest powers of the microscope. It can be filtered through a Berkefeld filter. It is destroyed by heating to 55° C. If the blood of a yellow fever patient, during the first three days, be inoculated into a healthy man he gets yellow fever, and it is only during the first three days that the blood is infective. On the other hand, the mosquito is incapable of transferring the disease until the unknown organism has been in its own body for at least ten or twelve days.

The mosquito in question belongs to the species *Stegomyia calopus* (Blanchard), or, as it is more often called in English text-books, *Stegomyia fasciata* (Fabricius). The genus *Stegomyia* differs from other *Culicidae* in having a dark grey or black colour, whilst the *Culicidae* are as a rule browner. *Stegomyia* also has silver-white spots and silver glistening scales, especially on the back of the legs and on the abdomen. The grown-up mosquito is com-

paratively small, and very elegant. Its length is some 3 to 4 mm., but if the mouth parts be added is some 6 to 6½ mm. long. As is usual, the male is smaller and feebler than the female. When settled—as, for instance, whilst sucking the blood of its host—it rests upon its first four legs only, the two hindmost being stretched out abaft like pennants waving in the air; but in general it has the hump-backed appearance of *Culex* and not the straight outline of *Anopheles*. The colour is greyish black, modified by numerous white spots and rings. There is a white rim round the eyes, and a very characteristic lyre-like pattern on the dorsal surface of the thorax. The structure of the mouth parts is much the same as that of any other *Culicidae*. The antennae have fourteen joints, the last two of which in the male are longer than the others. As is again usual, the antennae of the male have long brush-like hairs, organs by means of which they find the female. The legs are banded alternately with white and black rings. It is this character, indeed, which has given this mosquito the name of the 'tiger-gnat.' The wings are very iridescent.

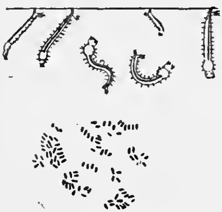

FIG. 27.—*Stegomyia fasciata*. Above, the larvae; below, the eggs. Both natural size.

The pupa of *Stegomyia* is darker and blacker than that of *Culex*, and, seen from the side, the head and the thorax are somewhat more triangular than the same parts in *Culex*. As the pupa grows older it grows darker. The length of the larva is 4 to 6 mm., somewhat larger than that of the gnat. But, like that, it has a respiratory-tube stretching out from the last segment of the abdomen, almost at right angles to the rest of the body. This respiratory-tube is much shorter than that of *Culex*, but is long enough to enable the larva to hang obliquely down into the water. The eggs are very large. They are covered by a mass of small 'cells' containing air, and they never tend to form a conglomerate mass like those of *Culex*, but are laid singly, and remain isolated until the larvae hatch. After floating a certain time they usually sink to the bottom of the water. Their length may be about a millimetre, and their colour is almost black. When the egg hatches, the anterior third of the shell splits off and the larva at once emerges.

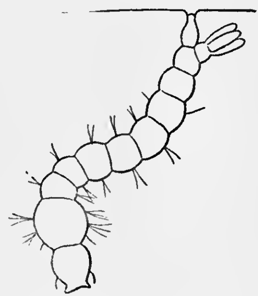

Fig. 28.—Larva of *Stegomyia fasciata* breathing on the surface of the water. Highly magnified.

As is so often the case with mosquitos, it is the female alone which bites. The male nourishes itself on plant-juices, saps, and so on—especially they like sugary secretions—and in the absence of blood the female is reduced to a similar diet. Hence *Stegomyia* is comparatively common in dwellings where sweetstuffs are—bakeries, sugar-refineries, and so on. These mosquitos are, like the cockroach, the fly, and the bed-bug, inhabitants of human dwellings. They are indeed domesticated, and are always to be found in the neighbourhood of human houses or buildings or ships, and are very rarely indeed found far away from the sphere of man's activities.

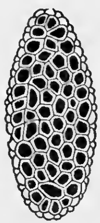

Fig. 29.—Egg of *Stegomyia fasciata* (highly magnified). Notice the air-'cells.'

They are very apt to bite one in the neck, creeping along the darker parts of the clothing until an unprotected region of the body is reached. Unless one has very thick socks they frequently bite the ankle, and they are as tireless in their pesterings as ever Mrs. Pardiggle was—no sooner are they driven away than they return to the attack. The bite is painful, and in many people raises a considerable swelling.

The *Stegomyia* bite not only during the night, but also during the day. According to R. O.

and O. Neumann—in Brazil, at any rate—they are capable of biting not only during the twilight, but at any times. The bite lasts twenty to thirty seconds, after which the mosquito rests a bit, waving its third pair of legs in the sun. After this rest she flies away to some sheltered spot, and whilst blood is being digested the mosquito takes nothing but water—a very proper dietetic measure. After three or four days the female is ready for another meal.

In the absence of man these mosquitos will suck blood from other animals, and in confinement they are generally fed on rats or canaries, and they will even suck up a drop of blood presented on a piece of cotton-wool.

If the female mosquito has been fertilised before the sucking of blood she will commence egg-laying two or three days later, and two or three days later again the larva will emerge. The larval stage lasts from nine to twelve days, and the pupa stage three to four, so that the whole metamorphosis takes from sixteen to twenty-two days. Hence, during warm weather, many generations succeed each other, but one must have a temperature of at least 20° to 27° C. Below that temperature the processes tend to slow down, and under a temperature near freezing-point the regular development is definitely interrupted. But

the interruption is only a suspense, and living activities are resumed should the temperature rise again.

It is a disputed point whether these mosquitos must have a meal of blood before they can lay eggs, and on this point the evidence is not yet sufficient to make a dogmatic statement. These mosquitos are very indifferent where their eggs are laid. The smallest collection of water in an empty sardine-tin, a broken tumbler, a puddle in the street, a gutter-pipe, is good enough for *Stegomyia calopus*. She will even lay her eggs on moist cotton-wool.

Although *Stegomyia* bites freely during the day-time, it, as a rule, avoids the light and seeks some dark shelter. Contrary to the habits of *Anopheles*, it prefers a light ground to rest upon. The larvae live on algae, vegetable-matter, or plant-detritus, or, in captivity, on white bread or Indian corn. They can remain for a considerable time without food, and this without materially diminishing the rate of their development. *Stegomyia* breeds well in ships, and is occasionally found in one part only of the ship—such as the engine-room or cook's galley, where the conditions seem to be most favourable to its development. Thus it comes about that at times certain quarters of a ship provide the greatest percentage of yellow-fever cases.

CHAPTER X

THE BISCUIT-'WEEVIL'[1] (*Anobium paniceum*)

'Let us be merry,' said Mr. Pecksniff. Here he took a captain's biscuit. 'It is a poor heart that never rejoices; your hearts are not poor. No!'—(DICKENS, *Martin Chuzzlewit.*)

THE first things to notice about the biscuit-'weevil,' so familiar to readers of Marryat's novels, is that it is not a weevil at all, and that it attacks a great many other comestibles besides biscuits. The so-called biscuit-'weevil' is in truth an *Anobium*—*Anobium paniceum*—a member of the family *PTINIDAE* and is closely allied to *A. striatum*, which makes the little round holes in worm-eaten furniture, so cleverly imitated by the second-hand furniture-dealers. Another species of *Anobium* (recently re-christened *Xestobium tessellatum*), a somewhat larger insect, is destructive in churches, libraries, and old houses. Their mysterious tappings (which are really efforts to attract the other sex—mere flirtations) are the cause of much superstitious dread in

[1] Modern systematists now call the biscuit-'weevil' *Sitodrepa panicea.*

the nervous, and this species is known as the 'greater death-watch.'

But to return to the biscuit-'weevil.' The mature insect is about a quarter of an inch long, and lives at large; it is the larva which burrows into and attacks the dried biscuit—the 'hard-tack' of the Navy. Less of a wood-borer than its allies, it nevertheless attacks almost any vegetable substance; and Butler tells us that 'rhubarb-root, ginger, wafers, and even so unlikely a substance as Cayenne pepper have been greedily devoured by it.' Several generations have been known to flourish on a diet of opium, and it has been found in tablets of compressed meat. Vegetable matter, even in an altered state—such as paper—affords it an ample meal; and in one case the larva of an *Anobium paniceum* bored steadily in a straight line through twenty-seven folio volumes in a public library, and so straight was the tunnel that a string could be passed through it from end to end. In one of our libraries at Cambridge some Arabic manuscripts were almost entirely destroyed by the larvae, which do not hesitate to browse

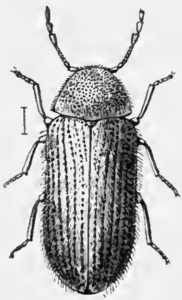

Fig. 30.—Biscuit-'weevil,' *Anobium paniceum*. (From David Sharp, *The Cambridge Natural History*, vol. vi.)

on drawings and paintings and the dried paper of herbaria.

The larva of this beetle is in truth a book-worm. Its interest for us in the present series is, however, the disastrous infestation of ships' biscuits, which frequently is so severe that

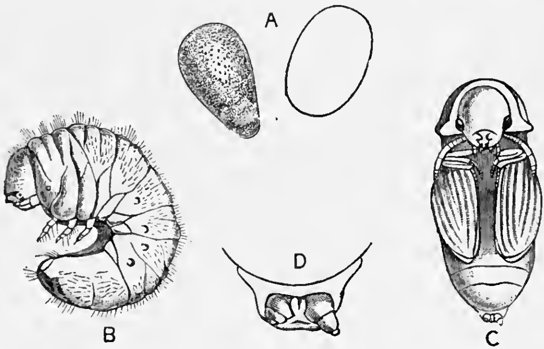

FIG. 31.—Early stages of *Anobium paniceum*. A, Eggs, variable in form; B, larva; C, pupa; D, asymmetrical processes terminating body of pupa. This larva is probably the 'book-worm' of librarians. (From David Sharp, *The Cambridge Natural History*, vol. vi.)

the sailors 'hard-tack' is rendered uneatable. Heating, of course, kills it; but the biscuits are still uneatable. The dead larvae are as unpalatable as the living. The contrivance of biscuit-tins since Marryat's time has done much to lessen the evils. Tradition has it that a great firm and a great fortune had their foundations laid, during the first half of the last century, by the accidental contiguity of a baker's shop and that of a tinsmith.

CHAPTER XI

THE FIG-MOTH [1] (*Ephestia cautella*)

All' amico mondagli il fico.
(*Italian Proverb.*)

THE extension of the War to Turkey and Asia Minor has drawn attention to the existence of certain insects whose larvae exercise a very deleterious effect on valuable food-supplies in the Near East. The inhabitants of Asiatic Turkey, without knowing it, have from time immemorial adopted the advice of Captain Cuttle: 'Train up a fig-tree in the way it should go, and when you are old sit under the shade on it. Overhaul the—— Well,' said the Captain, 'on second thoughts, 'I ain't quite certain where that's to be found, but when found, make a note of.'

Asia Minor may indeed be described as the fig-ground of the East, and anything that interferes with the fig as a food is likely to interfere with the well-being of our troops

[1] The figures illustrating this article are taken from *The Report of the Fig-moth in Smyrna*, Bul. 104. Bureau of Entomology, Washington, 1911.

in Egypt and the Near East. In 'The Minor

Fig. 32.—Typical Smyrna fig-orchard in Meander Valley, Asia Minor, whence come the best figs for export.

Horrors of War,' I described a species of moth, *Ephestia kühniella*, a member of the family Pyralidae, which infests and destroys Army biscuits; but this other species, *E. cautella*, which attacks figs, is even more troublesome

than the one described in the above-mentioned book.[1]

Whoever has attentively eaten dried figs must from time to time have become aware

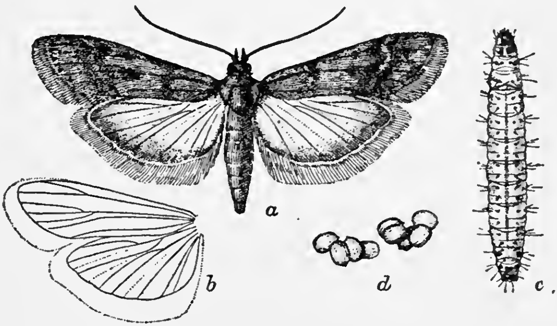

FIG. 33.—The fig-moth (*Ephestia cautella*). *a*, Moth with expanded wings; *b*, denuded wings showing venation; *c*, larva, full grown, dorsal view; *d*, two egg masses. *a*, *b*, *c*, About four times natural size; *d*, more enlarged.

that there is something very defective in their flavour, and on close inspection little

[1] It might be well to repeat the fact that the genus *Ephestia* blongs to the family *PYRALIDAE*, which is by most authorities included in the *Microlepidoptera*. The Speaker's sneer at the entomologists who work at this group (see his letter in *The Times* of February 2, 1916) is hardly worthy of one of the chief trustees of the British Museum. As a chief trustee, he must have been aware of the exhibit of the Microlepidoptera, *E. kühniella*, and its devastating action on the biscuits supplied to our soldiers by the War Office, which has for many months occupied a prominent position in the middle of the central hall of the Natural History Museum at South Kensington. This exhibit showed how closely the study of the Microlepidoptera is associated with the food-supply of our soldiers in many parts of the world.

clusters of débris will be observed on the outside of the dried fruit—the dejecta of the larva burrowing within—and numerous round holes can be detected through which the larvae have made their entrance. If cut open and carefully examined, one or two small white grubs may be found, which give the fig a singularly sour-bitter and most unpleasant taste. This is the larva of the moth, *Ephestia cautella* which has for the last four or five years been attracting much attention in the Levant market. From 15 to 50 per cent. of the figs exported from Smyrna, the great centre of the fig-trade, are infected with this 'worm,' and active steps were being taken before the War spread to the Near East to check its ravages. The moth itself is very like *E. kühniella*, but readily distinguished by an entomologist. Originally, it seems to have come from Asiatic Turkey, but by the aid of commerce it has been distributed in a broad belt all round the world within certain limits of temperature. Wide as its distribution now is, it is equally catholic in its tastes. Perhaps it does as much harm to the chocolate trade as to any other, attacking the cacao-bean as well as the prepared article; all sorts of nuts are infested. At one time it was thought that the oil of the nuts was the attraction,

but the larvae flourish just as well on rice and bran, on dried apples, dried insects, maize, and a great variety of other more or less nutritive substances.

But to return to the figs. So serious was the trouble felt to be in the American fig-market that, in 1910, the authorities at Washington sent Mr. E. G. Smyth of the Bureau of Entomology to investigate the insect in Asia Minor, where the figs come from, and from his report the following account is taken :—

> The manner of the fig-harvest is as follows: During August the figs are ripening on the trees, and are gradually dropping off to be collected from the ground and laid on strips of reeds, called 'serghi,' a yard broad, and here for two to five days they dry in the sun. When dried, they are packed in goats'-hair bags or woven willow baskets, and carried by horse or by camel to the fig-depots in the neighbouring villages. Here they are collected from the whole district, mixed together, and re-sacked for transmission by railroad to the coast. At Smyrna they are graded and prepared for the market: the better kind being either 'layered' or 'pulled,' whilst the inferior fruits are strung on strings or exported in the form of a mashed cake to make the 'strawberry' jam of the Western breakfast-table.

Mr. Smyth's object was first to find out at what stage the figs become infected by the moth, and then if possible to suggest pre-

ventive or remedial measures. He minutely investigated every stage in the preservation

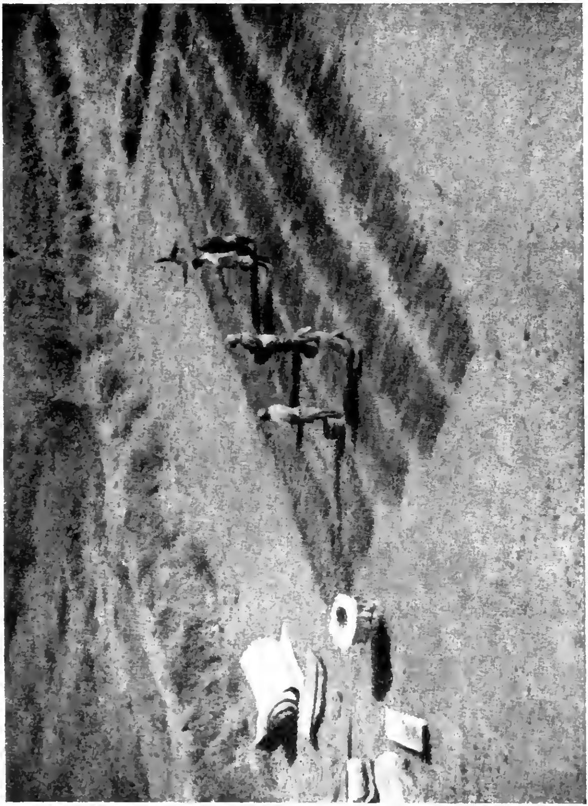

FIG. 34.—'Serghi' of reeds laid in long rows, used in large orchards. Over these the moths congregate by thousands at night.

of figs, from the ripe fruit on the tree to the preserved figs in the hold on the steamer bound for New York, and the conclusion he came to is this: With very rare exceptions

the eggs are never laid on the fruit whilst

Fig. 35.—Figs packed by string method (reduced).

on the tree. The first and by far the most important infection is when the figs are gathered and exposed on the reed 'serghi.' Then

about seven in the evening the moths begin to appear, and steadily increase in number as the evening wears on. The actual deposition of the ova cannot be observed, for the moths get down amongst the reeds and lay their eggs on the under surface of the fruit—usually in some crack or abrasion—so that the newly hatched larva can more easily make an entrance into the fig. From some 'counts' made at Tchifte Kaive it appears that after an exposure of one night 29 per cent. of figs were infested, after two nights 38·5 per cent., and after three nights 44·5 per cent.

A second and serious source of infection is at the village depots. Before the figs arrive, there seem to be no specimens of the *Ephestia* in the buildings; but with their arrival the moth appears, and so favourable is the shelter from the heat and the wind, and so abundant is the supply of figs as sack after sack is emptied on to the floor, that soon the moth is more abundant in the depots than amongst the 'serghi,' and the wonder is that a single fig escapes infestation. Fortunately, the time spent in the depots is short, often only a night; were it much longer, the whole crop would suffer. On their way down to the coast again there is little or no risk of the moth, but arriving at Smyrna

we pick up the insect again in the 'khans,'

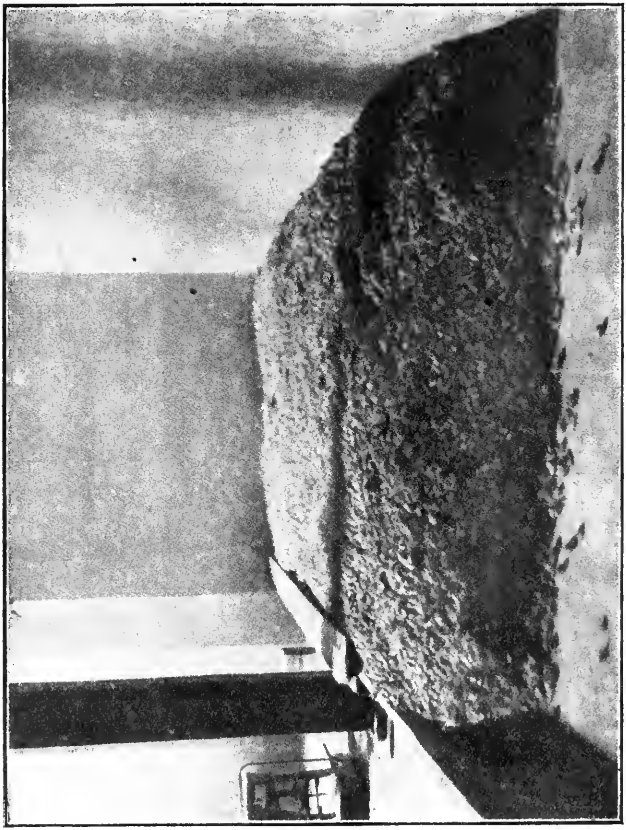

FIG. 36.—Pile of refuse-figs in a Smyrna 'khan.' On the wall, above these figs, fig-moth larvae congregate in large numbers.

where the figs are prepared for export, but in the larval form. Here, in August and September, little trace of the insect is seen, the larvae are then too small to emerge and pupate; but by October many full-grown

larvae may be found on the fig-heaps or crawling up the walls; a few pupate inside the figs, and these probably produce the few imagines found in the 'khans,' at the port of shipping. The unpleasantness of the larvae crawling all about the ship greatly detracts from the pleasure of a voyage on a vessel laden with Smyrna figs.

With regard to preventive measures, there seems in many parts of Asia Minor to be two crops of figs—one in May and June and one later. The former produces a large, watery fig, unfit for sale. It is left to rot on the ground, but it serves as food for the larvae which will produce the myriad swarms of moths in the early autumn. Obviously these worthless figs should be destroyed as completely as possible. Equally obvious are the suggestions that the figs should be covered at night with some cheap covering whilst on the 'serghi,' and screened from the moth whilst in the depots, and their sojourn there should be as short as possible. Measures for destroying the larvae in the fig usually take the form of heat—either hot air, hot water, or steam. Each is effective, and each has certain advantages and disadvantages; still, the more progressive merchants of Smyrna were, before the War, experimenting trying to find the best means of destroying the larvae, and in time a uniform system will probably emerge.

CHAPTER XII

THE STABLE-FLY (*Stomoxys*)

Fly! Thy brisk unmeaning buzz
Would have roused the man of Uz;
And, besides thy buzzing, I
Fancy thou'rt a stinging-fly.
Fly—who'rt peering, I am certain,
At me now from yonder curtain:
Busy, curious, thirsty fly
(As thou'rt clept, I well know why)—
Cease, if only for a single
Hour, to make my being tingle!
Flee to some loved haunt of thine;
To the valleys where the kine,
Udder-deep in grasses cool,
Or the rushy margined pool,
Strive to lash thy murmurous kin
(Vainly) from their dappled skin!

(CALVERLEY; *The Poet and the Fly*.)

THE common names for common insects in English are confusing. Not only are the same insects frequently known by different names on different sides of the Atlantic, but in many cases quite different insects—insects even belonging to different genera—are connoted by the same common name. In this respect matters are different in Germany: partly,

perhaps, because the Germans on the whole are more scientifically inclined than we are, but partly, I suspect, because the German language lends itself more easily to express

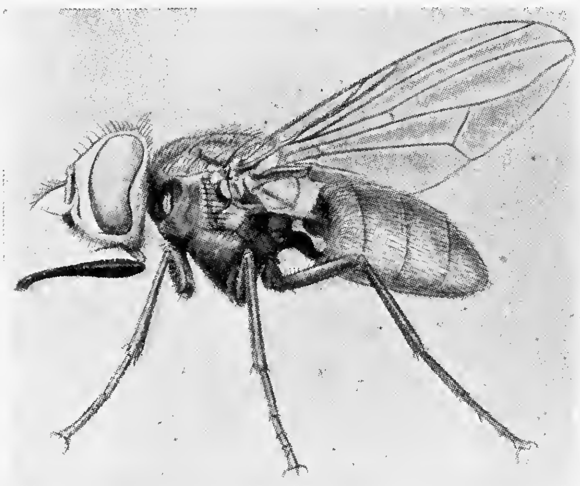

FIG. 37.—The Stable-fly (*Stomoxys calcitrans*).

in one word—however long—the characteristics of any given insect.

The genus *Stomoxys* is generally called in Great Britain the 'stable-fly,' but there are other 'stable-flies.' One of the commonest species of the genus is *S. calcitrans*, a two-winged muscid fly, not at all unlike the common domestic fly, *Musca domestica*; but there are one or two points which readily distinguish

it from the commoner insect. To begin with: it has a hard, firm, chitinous, piercing proboscis, which when at rest stretches forward in front of the head, and when in action is pressed down at right angles to the longitudinal axis of the body; then, again, when

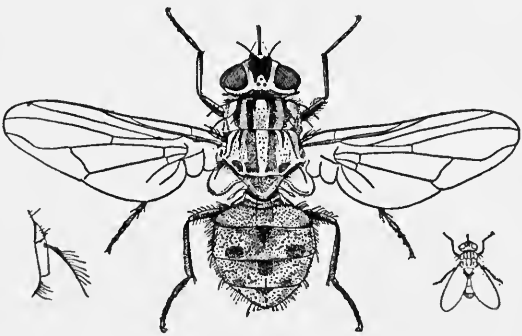

FIG. 38.—*Stomoxys calcitrans* × 5. Left antenna right × 1, resting position. (From Graham Smith.)

resting, its wings diverge; those of the house-fly approximate. Like other flies, the *Stomoxys* varies somewhat in length, between 5·5–7 mm. The thorax has on its back four longitudinal, dark stripes, broken by a transverse suture; and, as the accompanying figure shows, the third of the great, long veins which traverse the wing is much more slightly bent than is the case in *Musca domestica.* Further, whereas the hinder edge of the eye in the house-fly is straight that of the stable-fly

is concave, and the antennae bear hairs on the upper side only and not above and below as they do in the domestic fly.

As a biting-fly and a blood-sucking fly, the habits of *Stomoxys* naturally differ from those of *Musca domestica*; but, like the latter,

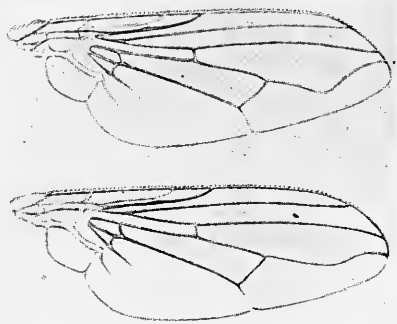

Fig. 39.—Wing of *Musca domestica* above, and of *Stomoxys calcitrans* below.

its distribution is almost world-wide. It is found in all temperate and tropical countries, and extends as far north as Lapland. But it is perhaps most abundant (or shall we say it has been most observed?) in temperate climates and during the summer months.

In any farm or country house large numbers of *Stomoxys calcitrans* are found in and about the cowsheds and stables, and in warm weather the same is true wherever cattle are grazing

in the field. Later in the year, at the beginning of autumn, they are frequently found indoors, and in some 'fly counts' they have furnished quite 50 per cent. of the flies of a country house, the remaining 50 per cent. being made up of many other species and genera. When resting on a vertical surface *Stomoxys* generally has its head pointing upwards, whereas, as a rule, the house-fly rests upside down. The adult fly feeds upon any decaying matter; but whenever it can, it sucks the blood of vertebrates, and at times is a real nuisance to animals as well as human beings. So voracious are they that should a well-fed one be injured, the others immediately attack it and suck up every drop of blood which it had secured for its own food.

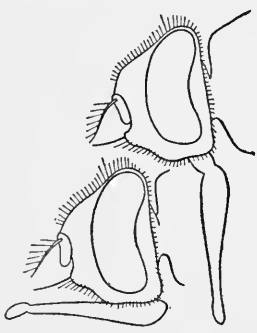

FIG. 40.—Side view of head of *Stomoxys calcitrans*. A, Proboscis in resting position; B, proboscis extended. (After Graham Smith.)

It has often been disputed whether a meal of blood is essential to the female mosquito before oviposition, but it seems perfectly clear that the female *Stomoxys* can produce fertilised eggs without having had a meal of blood.

The female lays a number of white, banana-shaped eggs a few inches below the surface of any decaying organic matter; fermenting grass from the lawn, decaying garden stuff, stable manure—each forms a favourable nidus.

FIG. 41.—*Stomoxys calcitrans*. Eggs. (After Newstead.)

The eggs are laid in a heap like those of the house-fly, each heap containing from fifty to seventy. The egg is 1 mm. in length and has a grooved side, through the thicker end of which the larva escapes when the egg-shell splits.

The issuing larva is almost transparent. It not only has no head, but the anterior end dwindles almost to a point. When fully

grown it attains a length of 11 mm., and the larval stage usually lasts from two to three weeks; but development may be retarded by adverse circumstances up to eleven or twelve weeks, and in such cases the full-grown larvae are often stunted in size. In these circumstances the pupae they produce are markedly smaller than those which have followed a more normal course of development. As is true of the egg and of the larva, the pupa resembles the pupa of the house-fly, being barrel-shaped and of a chestnut-brown colour; it is 5 to 5·5 mm. in length. The pupa stage lasts from nine to thirteen days, but this period is prolonged by cold.

Fig. 42.—Acephalous larva of *Stomoxys calcitrans*. (After Newstead.)

On emerging from the pupa-case the insect has to push its way to the surface of the rotting vegetation in which it has been produced. This it does partly by the alternate inflation and deflation of the so-called ' frontal sac,' and by actively pushing forward the body by means of its legs. Once on the surface the insect begins to clean itself, pumps

air into its body, forces it along the tracheae in the wings, which expand and ultimately harden. In the processes of unfolding they are aided by the hind legs. For a time the insect is immobile, gradually stiffening; but when the integument has hardened it flies off to explore the outer world. Under normal conditions the whole life-cycle varies from twenty-seven to thirty-seven days.

Fig. 43.—Coarctate pupa of *Stomoxys calcitrans*. (After Newstead.)

The chief interest of *Stomoxys* to the public, rests upon the fact that it is a very potent carrier of disease. There are certain forms of *Trypanosoma* which, under experimental conditions, are undoubtedly transferred by this species. But opinion is still unsettled as to whether the transference of these protozoa occurs in nature. The *Surra* diseases of horses and camels is, according to some authorities, transferred by *Stomoxys*, and so is the *Surra* disease of cattle; and there are others, all fully set forth in Mr. Hindle's work on 'Flies and Disease.'

Certain thread-worms—for instance, *Filaria labiato-papillosa*—which occur in the peritoneal cavity, and sometimes in the eyes of cattle and deer in India, are undoubtedly conveyed by *Stomoxys calcitrans*. The super-

ficial vessels of the cattle swarm with the larvae of these thread-worms, which readily pass through the proboscis of the insect into its stomach. They then wriggle through the walls of the stomach and make their way into the thoracic muscles; here they undergo a 'rest-cure,' and after a time they are readily transferred to a new and possibly uninfected host.

But by far the worst infection which is attributed to this fly is acute epidemic poliomyelitis, or infantile paralysis. That this disease occurs in epidemics has been known—especially in Scandinavia—for some time; and eight years ago it attracted serious attention in North America and in our country. In 1907 there were many local outbreaks in the United States and Canada, and it is thought that the infection was first introduced from Scandinavia along the Atlantic coast, and later, inland, as far as the State of Minnesota, by the numerous Scandinavian immigrants that settle there.

The disease is one of those which are apparently due to a protozoon too small to be visible under the highest power of the microscope, and so small as to be able to pass through a Berkefeld filter. It can readily be artificially transmitted to monkeys. It is thought that the disease is by no means

transmitted only by means of the biting *Stomoxys*, and that it may be directly transmitted from one person to another without the aid of any intermediate host. But there seems little doubt that it can be, and is, transmitted by *Stomoxys*, and therefore it is of the highest importance to reduce the number of these insects.

The most efficient way of controlling this pest is to destroy or put out of action its breeding-places. All decaying vegetable matter should be either removed or burnt or buried, or covered with some agent which will prevent the larvae living. In fact, the methods that have been advocated for the common house-fly are applicable to *Stomoxys*. If stable manure were carefully removed, from May to October, at least every seven days, the number of flies would be materially reduced. Where this is impracticable, manure-heaps should be covered with some insecticide, so as to destroy the eggs and larvae. Experiments are still being made with the view of finding a substance capable of killing the eggs, larvae, and pupae, which will be at once cheap and unharmful to the fertilising value of the manure. The American experts recommend borax or colemanite (crude calcium borate), calcined, powdered, and applied by a flour-dredger. The proportions which seem

most effective are 0·62 lb. of borax and 0·75 lb. of colemanite to 10 cubic feet, or 8 bushels of manure. Two or three gallons of water should then be sprinkled over the manure-heap.

CHAPTER XIII

RATS [1] (*Mus* or *Epimys*)

Now, Muse, let's sing of rats!

(GRAINGER.)

THE overwhelming majority of rats fall under two species: (i) *Mus rattus*, the black rat, and (ii) *Mus decumanus*, the brown rat. The original home of both species is, according to Dr. Blandford, Mongolia; but the date of their first appearance in our islands is a matter of some uncertainty. According to Helm, *M. rattus* passed into Europe at the time of the *Völkerwanderung*, and doubtless accompanied the migrating Asiatic hordes on their journeys westward. The name rat appears in early High-Dutch glossaries, it is mentioned by Albertus Magnus, and occurs in early Anglo-Saxon writings in England. This evidence is, however, not conclusive that in those times the rat had entered Great Britain; indeed, according to Bell,[2]

[1] The modern systematist now calls the black rat *Epimys rattus*, and distinguishes two varieties—*E. rattus alexandrinus* and *E. rattus rattus*; the brown rat is now *E. norvegicus*.

[2] *A History of British Quadrupeds*, 2nd ed. London, 1874.

the black rat was not known here until before the middle of the sixteenth century: at least, he says, no author more ancient than that period has described, or even alluded to, it as being in Great Britain, Gesner being the first to do so. Jenyns, in his 'Manual

FIG. 44.—*Mus rattus*. (From Pennant.)

of British Vertebrate Animals,'[1] describes *M. rattus* as 'truly indigenous'; but this is in comparison with the brown rat, whose comparatively recently arrival he chronicles. *M. rattus* is said to have been common on the continent of Europe in the thirteenth century.

M. rattus has, as a rule, greyish-black fur above, ash-coloured below, with a tail a

[1] London, 1833.

little longer than the body and head. It is smaller and more elegantly built than the brown rat; its snout is longer and more slender, and the long, thin, scaly tail is about eight or nine inches in length. The British forms average in length seven inches from the tip of the nose to the origin of the tail. Although known as the black rat, its bluish, or greyish-black colour is, both in the East and in Northern America, frequently replaced by brown on the upper surface, and by white fur on the lower, or by a yellowish-brown rufous colour. The ears, feet, and tail are black. When kept as pets—and they frequently are—white and piebald varieties are often bred. The ears are larger in proportion than in *M. decumanus*, the rings of scales on the tail better marked, and spines in the fur are not uncommon.

The black rat, or Old-English rat, begins to breed under the age of one year, and goes with young six weeks; it breeds frequently during the year, but does not commence in Bombay, according to the Plague Commission, until it has attained the weight of at least 70 grammes. In India they breed all the year round. In Britain they produce six to eleven young at a time; in India the average is 5·2; the largest number found by the Plague Commission having been nine. In Bombay it is noteworthy that in both species the percentage

of young rats to the total rat population is greater during the warmer months—from June to October—than at other times of the year. It is also noteworthy that the fall in fertility begins before the onset of the plague epizootic, though, later, it roughly coincides with it. In Britain they increase so fast as to overstock their abode, and thus they are forced, from deficiency of food, to devour one another, and

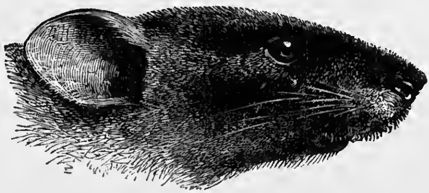

FIG. 45.—Head of *Mus rattus*. (From Flower and Lyddeker.)

this alone, Pennant thinks, 'prevents even the human race from becoming a prey to them, not but there are instances of their gnawing the extremities of infants in their sleep.'

The black rat is catholic as to its diet, omnivorous, and it devours every kind of human food. It is more domesticated than its congener, more devoted to human habitations, and it does immense damage to stored grain, seeds, and cereals. It is a better climber than *M. decumanus*, which accounts for its being *par excellence* the ship-rat, since it can climb hawsers and more readily 'comes

on board.' It makes its way up to the higher rooms of the tenement houses in Indian cities, where it nests and breeds undisturbed by the human inhabitants.

> Day by day we passed them—
>   Met them unaware,
> Shambling through the lobbies,
>   Squatting on the stair.
>
> Not a rat among them
>   Moved to give us place,
> Staring with its cruel eye
>   And its aged face.
>
> (F. Langridge.)

Pennant[1] draws attention to the harm the black rat causes by gnawing and devouring not only edibles, but paper, cloth, water-pipes, and even furniture. In England it makes a lodge—either for the day's residence or a nest for its young—near a chimney, and 'improves the warmth by forming in it a magazine of wool, bits of cloth, hay, or straw.' In the East it nests in the indescribable rubbish and 'unconsidered trifles' the natives accumulate in their rooms, and is seldom, if ever, interfered with.

Its climbing-habits enable it to ascend trees, and in India it frequently nests among the branches. In some tropical islands *M. rattus*

[1] *British Zoology.* London, 1812.

lives exclusively in the crowns of coco-nut palms, feeding almost entirely on their fruit.

Contrary to the opinion of Blandford, Oldfield Thomas thinks that the black rat originally came from India, and thence spread all over the world, exterminating the indigenous rats of other countries, only to be exterminated later by the arrival of the stronger *M. decumanus*. At the present time the last-named species is not yet established in some countries —for instance, in those of western South America. On that continent, *M. alexandrinus*, a tropical variety of *M. rattus*, is waging war on the less highly organised native rice-rats (*Sigmodon*). *M. alexandrinus* has a grey or rufous back, and a white belly.

M. rattus has a milder, more amenable, and tameable character than *M. decumanus*, and the white, or pied varieties, so dear to schoolboys, are of this species. It is cleanly in its habits, and the skin is kept in excellent order. Like other rats, it holds its food in its hands whilst eating, and it drinks by lapping.

Although the black rat is tending to be driven out by the brown rat, it still lingers on in some warehouses in London, at Yarmouth, in Sutherlandshire, I believe in Lundy Island, and I have been told it occurred not so very long ago on the island in the Serpentine. It doubtless occurs in many other places.

Mus decumanus, the so-called brown rat, undoubtedly comes from Central Asia; and at the present time there is a rat in China described under the name *M. humiliatus*, which is so little distinguishable from the brown rat that it is thought to be the parent form.

The migration westward of the brown rat certainly took place much later than that of *M. rattus*. Its first appearance is difficult to date. Undoubtedly large hordes of them crossed the Volga in the year 1727, and continued their journey towards Central Europe, The following year, according to Pennant, brown rats, appeared in England—Jenyns says not till 1730—and almost certainly they came in ships, for on its journey overland it only reached Paris about the year 1750. Reaching England about the year of the second George's accession, and but thirteen years after the first of the House of Hanover succeeded to the throne, it was called—probably by the adherents of the Stuart cause—the Hanoverian rat. It was also called the Norwegian rat—possibly from the mistaken idea that it reached these islands from that country. It has now passed to the northern half of the New World, where it is gradually driving out many of its weaker brethren. Its numbers are, however, kept within certain limits by wolves, lynxes, racoons, coyotes,

opossums, and other carnivora, and especially by the skunks, which enter barns and outhouses in search of it.

Until the discovery of America, the rat and mouse were unknown in the New World, and the first rats who ever saw it are said to have been introduced in a ship from Antwerp.[1]

The brown rat is of a greyish-brown colour, tinged with yellow and white beneath. The tail is not so long as the body. It is a larger rat than *M. rattus*, has shorter ears, a more powerful skull, and ten to twelve mammae. Its ears, feet, and tail are flesh-coloured. Like *M. rattus*, colour varieties occur often: the melanistic variety, not uncommon in Ireland, being sometimes mistaken for the black rat. It is a larger animal than its congener, more heavily built, with a more powerful head, and blunter jaws. The head and body measure some eight to nine inches, but the tail, as a rule, does not surpass the length of the body alone. Its weight averages about nine ounces. It is extremely fierce and extremely cunning, and in the struggle for existence with allied species has hitherto been consistently successful in the fight.

Mus decumanus is very prolific, and produces several litters a year, each averaging eight to ten in number, but twelve or even fourteen

[1] Ovalle's 'History of Chili,' in *Churchill's Voyages*, vol. iii, p. 45.

young are not very uncommonly born at one time. It begins breeding young—a half-grown female producing a litter of three or four; but in Bombay the sexes do not breed until they have attained at least a weight of 100 grammes. The young are naked, i.e.

FIG. 46.—*Mus decumanus*. (From Pennant.)

without hairs, and of a beautiful pink colour. They are blind, and their ears are gummed down over the auditory meatus. They are very weak and helpless, and need that maternal care, which, to do the female rat justice, is never withheld.

M. decumanus is less attached to the dwellings of man than *M. rattus*; still, it does live in houses, though, owing to a lack of climbing power, it is never found above the third floor.

It is largely a burrowing animal, and makes its nests in its burrows. *M. rattus* can also burrow, but not so readily, and it nests not in the burrow, but in some obscure corner. A curious instance of the nesting habits of this species was found during the rebuilding of my ‘ lodgings ’ in 1911. In searching under the boards of the floor of the rooms of our Foundress the Lady Margaret, Mother of Henry VII, now the drawing-room, the workmen found the mummified remains of four rats, which had taken to themselves coverings or shrouds; and upon investigation these proved to consist of a vellum deed relating to the College, some paper documents relating to Thomas Thompson, who was Master of the College from 1510 to 1517, and some fragments of printed matter which turned out to be part of an early Virgil; four leaves of a Horace; two leaves of a primer of Wynkyn de Worde; and finally a leaf of a work by Caxton. In addition, four playing-cards of the sixteenth century were found.

The brown rat frequents barns, granaries, stables, slaughter-houses, rivers, ponds, ditches, drains, gullies, and sewers—it is, in fact, sometimes called the sewer-rat. It is less particular in its food than the black rat, which is more usually found in grain-stores. Although in Bombay the relative numbers

of *M. rattus* and *M. decumanus* caught was as seven is to three, in open spaces, gardens, &c., the latter was much the commoner. Yet the report of the Plague Commission states that the authors 'do not think it an exaggeration to state that every inhabited building in Bombay City and Island, not

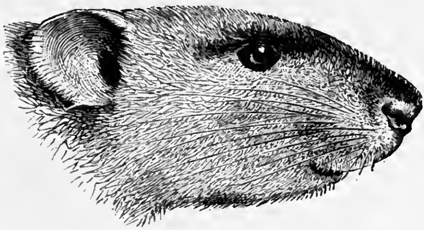

FIG. 47.—Head of *Mus decumanus*. (From Flower and Lyddeker.)

excepting even the better-class bungalows, shelters its colony of *M. rattus*.'

Both species readily take to water, though *M. rattus*, being the better climber, more readily gets on shipboard. They will swim rivers and arms of the sea. The rats which infest the London Zoological Gardens are said to swim nightly the canal in Regent's Park. Rats constantly make their way to coastal islands, and in a comparative short time clear the place of indigenous rabbits and birds. Puffin Island, off the coast of Anglesea, and the Copeland Islands, in Belfast Bay, are two examples of islands at one time

leased for the sake of their rabbits to people who had to give up the lease after the rats had landed on them. Similar cases are known off Denmark. They greedily eat birds' eggs, and are said to convey them over considerable distances, though how they do this is not very clear. After the destruction of the vertebrate land-fauna, they fall back upon the dwellers in the littoral, and live on prawns, shrimps, and molluscs. They are very fond of fish, and Lyddeker, in the 'Royal Natural History,' states that they occasionally catch and eat young eels. As their parasites show, they eat insects such as the meal-beetle, and when in the field they eat land-snails, insect larvae, and other food, which conveys into their bodies the same tape-worms, &c., which we find in the hedgehog and in the smaller carnivora.

They are, in fact, omnivorous, and nothing in the way of human food is alien to them. They do enormous harm to corn-ricks and to stored grain. They are inveterate enemies of the hen-roost, the pigeon-house, and, as we have seen, of the rabbit-warren. When pressed by hunger, they readily turn cannibal, and the brown rat easily masters the black. There are stories of some few specimens of each species being left in a cage overnight; on the following morning there were only

brown rats in that cage. To some extent they help to keep down one of the field-mice (Genus *Microtus*), and this is especially the case in North America;[1] but the benefit is doubtful since they are held to be at least as destructive to the crops as the field-mice, and probably more so.

The ferocity with which they defend themselves when attacked is well known, and at times, when they are driven by hunger, they do not hesitate to attack man. They are said to nibble the extremities of infants, and in one—apparently authentic—instance they overcame and devoured a man who had entered a disused coal-mine tenanted by starving rats. The bite is said to be severe (they will bite through a man's thumb-nail into the flesh), and the bite is long in healing.

Rats eat much garbage and offal, and readily feed upon dead bodies. About sixty years ago there stood, at Monfaucon, a slaughter-house for horses, and this it was proposed to remove still farther from Paris. It is stated that the carcasses of the horses slaughtered—which sometimes amounted to thirty-five a day—were cleared to the bone by rats in the course of the following night. This excited the attention of a M. Dusaussois,

[1] 'An Economic Study of Field-mice (Genus *Microtus*).' By Dr. Lantz, in *U.S. Dept. of Agric., Biol. Survey*, Bull. 31.

who made the following experiment: He placed the carcasses of two or three horses in an enclosure, which permitted the entrance of rats by certain known and closable paths. Towards midnight, he and some workmen entered the enclosure, closed the rat-holes, and in the course of that night killed 2650 rats. He repeated the experiment, and by the end of four days had killed 9101 rats, and by the end of a month 16,050 rats. During the process of these experiments other carcasses were exposed in the neighbourhood, so that in all probability M. Dusaussois attracted to his enclosure but a small proportion of the total available number of rats. All around this slaughter-house the country was riddled with extensive burrows, so that the earth was constantly falling in. In one place the rodents had formed a pathway, 500 yards long, leading to a distant burrow.

A rat census can never be taken; but, estimating that there is one rat for every human being on these islands, or less than one rat for every acre of ground, a moderate estimate would give us 40,000,000 rats at any one time. It has been calculated that a rat does at least 7*s.* 6*d.* worth of damage during the course of the year: hence in Great Britain and Ireland, we may annually charge them with a loss of at least £15,000,000!

From what has been said it is obvious that rats cause enormous damage to humanity, which is counterbalanced by the almost infinitesimal good they do as scavengers. I do not propose to consider in detail the harm they do as disease-carriers, but one cannot forget that the rat is the primary host of *Trichinella spiralis*, which, when conveyed from the rat to the pig, and—by eating uncooked or imperfectly cooked pork—from the pig to man, causes severe and very fatal epidemics, and enforces the expenditure of large annual sums on meat inspection. They further convey a virulent form of equine influenza from one stable to another, and also the 'foot-and-mouth' disease. But what is infinitely more important to man than all the other injuries put together is the harm they bring to suffering humanity by conveying the bubonic plague from one patient to another. The plague under which India and great parts of Burma are 'groaning and travailing,' is caused by a specific bacillus discovered in 1894 by Yersin at Hong-Kong. It flourishes in other vertebrates besides man and the rat, but, owing to the migratory habits of the latter, the rat is the most effective agent in the spread of the disease. Both species of rat seem about equally susceptible, and the presence of the microbe showed no

special relation to either the age or the sex of either species. The microbe is conveyed from rat to rat and from rat to man by a flea.

The destruction of the rat is now being urged on all hands, and in the near future we shall probably see a considerable diminution in their numbers in the more civilised countries of the world. This will mean a considerable upset in the balance of power of the almost hidden fauna which surrounds us on all hands. It may even, as the Medical Officer of Health for Bristol has pointed out, lead to an increase of immigration of ship-rats—those most likely to be infected by plague—to take up the places vacated on land by the slain. By one of those commercial agencies—I do not propose to go into the merits of any one of them—which the enterprise of our merchants is now pressing on the public, a large landed proprietor a few months ago completely freed his buildings of rats and mice. A few weeks later his house and out-buildings were overrun by swarms of what to him—for in the time of the rats and mice he had never seen one—was a new and formidable insect. He sought the aid of the Royal Agricultural Society, who referred the matter to their scientific adviser, who pronounced the insects to be cockroaches!

Mr. H. Warner Allen, the representative of the British Press with the French Army, writes as follows in the *Morning Post*:—

Of the smaller trench annoyances few are more worrying than the plague of rats. Shelters and trenches, no matter where they are made, whether in woods or open fields or on the mountain-side, become immediately infested with the objectionable creatures. In one case within my own personal knowledge they drove a French officer out of a comfortable and commodious dug-out into a damp and melancholy shelter, which was to some extent protected from them by sheets of corrugated iron. The plague had attained considerable dimensions before a really organised attempt was made to deal with it, and there were many cases of rats actually biting men who were chasing them down the trenches.

Terriers have proved of considerable assistance. Trains full of dogs have been dispatched to the Front, and poison has been fairly effective. Lately, a reward has been offered for every dead rat brought in by men in the trenches, and regular battues have been organised. In a single fortnight one army corps alone has disposed of no fewer than 8000 rats. At a halfpenny a rat this has involved an expense of £16, and it was certainly money well spent. The sport of rat-catching on such very advantageous terms has proved very popular among the men, who now suggest that the standing reward offered for the more dangerous and more exciting form of sport involved in the capture of a German machine-gun should be raised to a higher figure.

Ferrets have been largely used in the British trenches, but their price is now very high, and the supply is very limited. The method which has had some success in

combatting the rabbit-plague of Australia—killing all captured females and let all captured males loose—is certainly worth a trial. Rats will gnaw through concrete, but not if plenty of pieces of broken glass be mixed with the concrete. They will never cross a band of tar which has been kept liquid by mixing with grease. In the French trenches, special rat-runs are dug and these are provided with 'live' wires. On touching one of these the rat is electrocuted.

In the eighteenth century, among the officers of his 'Britannic Majesty,' was an official rat-catcher, whose special uniform was scarlet, embroidered in yellow worsted with figures of field-mice destroying wheat-sheaves. Inquiry at the Lord Chamberlain's office has satisfied me that the officer still exists and still catches rats, but I fear the uniform has been abolished. However, a book has recently appeared dealing officially and exhaustively with all matters of this kind, and as soon as I can come by it, I will look the matter up. Should this dignified uniform have really disappeared, might not a humble petition be presented that it be revived? Surely, never more than at the present time should the honour and glory of the rat-catcher be exalted!

CHAPTER XIV

THE FIELD-MOUSE (*Apodemus sylvaticus*)

TO A FIELD-MOUSE

On turning Her up in Her Nest with the Plough,
November 1785.

Wee, sleekit, cowrin', tim'rous beastie,
Oh, what a panic's in thy breastie!
Thou needna start awa' sae hasty,
Wi' bickering brattle!
I wad be laith to rin an' chase thee,
Wi' murd'ring pattle!

I'm truly sorry man's dominion
Has broken Nature's social union,
An' justifies that ill opinion
Which maks thee startle
At me, thy poor earth-born companion,
An' fellow mortal!

I doubt na, whyles, but thou may thieve;
What then? poor beastie, thou maun live!
A daimen icker in a thrave
'S a sma' request;
I'll get a blessin' wi' the lave,
An' never miss 't!

Thy wee bit housie, too, in ruin!
Its silly wa's the win's are strewin'!
An' naething now to big a new ane
O' foggage green!
An' bleak December's win's ensuin',
Baith snell an' keen!

Thou saw the fields laid bare an' waste,
An' weary winter comin' fast,
An' cozie here, beneath the blast,
Thou thought to dwell,
Till, crash! the cruel coulter past
Out thro' thy cell.

That wee bit heap o' leaves an' stibble,
Has cost thee mony a weary nibble!
Now thou's turn'd out for a' thy trouble,
But house or hauld,
To thole the winter's sleety dribble,
An' cranreuch cauld!

But, Mousie, thou art no thy lane,
In proving foresight may be vain:
The best-laid schemes o' mice an' men
Gang aft a-gley,
An' lea'e us nought but grief an' pain
For promis'd joy.

Still thou art blest, compared wi' me!
The present only touches thee:
But, och! I backward cast my ee
On prospects drear!
An' forward, tho' I canna see,
I guess an' fear.

(Burns.)

Another member of the *Muridae*, the field-mouse (*Apodemus sylvaticus*), is almost as great a nuisance in the trenches as the rat. The field-mouse is very like the house-mouse, with some of its features seen under a lens. The hind feet and ears and eyes are larger than are those of the house-mouse. Perhaps its much longer hind legs help most easily to differentiate the two species. The tail is of

about the same length as the body and head added together, and is annulated, presenting some 150 rings. The hands have five-palmar pads, and the feet six pads. There are six mammae in the female, the anterior pair being pectoral.

The general colour of the dorsal surface is described as wood-brown, which pales at the front end and towards the shoulders and flanks, and grows to a more reddish tinge at the posterior end. The whole of the lower surface is of dull, white, silvery colour, and on some well-developed specimens there is a spot of buff, or orange, on the throat, which sometimes lengthens out to form a collar. Moulting seems to be rare—at any rate but a few cases have been recorded.

The field-mouse occurs all over Europe, and extends into parts of Asia. It is found all the way from Iceland, southward to Algiers, and from Ireland to India. In the Himalayas it has been taken at a height of 11,500 feet, and in the mountains of Europe it frequently occurs at a height of 7000 feet. It is certainly the most universally distributed of European animals, and the number of individual specimens probably far exceeds that of any other mammal which occurs in its district.

The field-mouse does not hibernate like the dor-mouse, but is active and hardy at

all seasons of the year. Although, like other *Muridae*, it is probably vegetarian by ancestry, it is, in effect, quite omnivorous. It

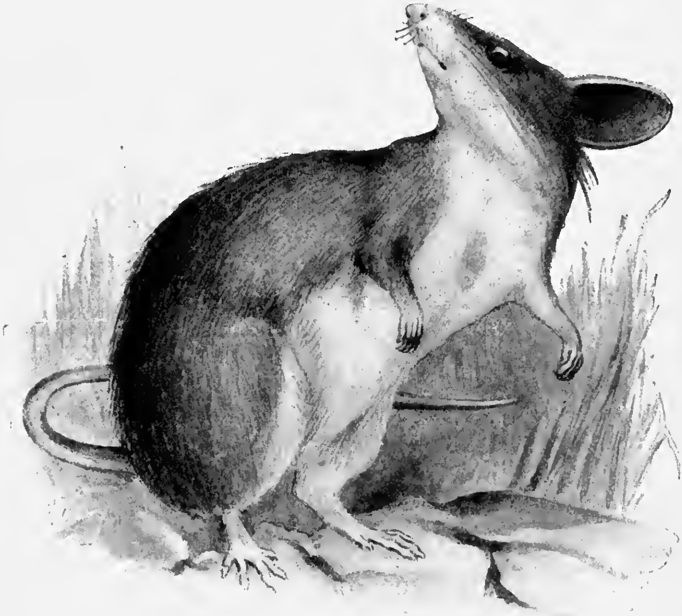

Fig. 48.—The field-mouse (*Apodemus sylvaticus*). (From Barrett Hamilton.)

causes considerable loss in cornfields and gardens, especially to early-sown peas; it eagerly eats dandelions and any kind of grain or nut, or berry, or fruit, or bulb, or bud. Even fungi have been found in their winter stores; and one family was discovered which had eaten considerable quantities of putty with appar-

ently no deleterious effect. Their fondness for bulbs is a great nuisance to the Dutch tulip-merchants. As many as 300 have been trapped in a fortnight in a single crocus-bed. They are also a nuisance to bee-keepers, inasmuch as they enter the hive and eat the honeycomb, especially during the winter. Whilst feeding in the hedgerows, or undergrowth, they frequently establish themselves in birds' nests, and occasionally such nests become their permanent home.

> In the hedge-sparrow's nest he sits,
> When the summer brood is fled,
> And picks the berries from the bough
> Of the hawthorn overhead.
>
> (*Sketches of Natural History*, 1834.)

They are not above sucking the birds' eggs, or even devouring the young birds. They will sometimes enter disused tunnels and devour hibernating flies and other insects. Unlike rats, they seldom enter human habitations, and they are quite innocent of the peculiar odour which is so disagreeable in the house-mouse; and unlike the house-mouse and the harvest-mouse they are seldom found in stacks of corn. Their preference for berries explains the fact that they generally haunt woods and hedgerows, and their passion for growing corn accounts for the fact that they swarm in cornfields towards harvest-time.

The field-mouse, however, does not neglect open and barren districts, and is found from the sea-beach to the mountain-tops. It seems to flourish equally well in the flower-beds of the London parks and on the lonely hills of Scotland. Its activities are largely confined to the night-time, which may account for the exceptional size of its eyes. It is described 'as bounding along in a peculiar zig-zag and erratic manner, remotely resembling the movements of a kangaroo or jerboa.' Its spoor is very characteristic. The hind feet pressing nearly on the same spot as the fore feet, but less lightly than the latter. From time to time it sits upright, pricking its ears; and obviously its sense of hearing is very acute, for it distinguishes sounds inaudible to the human ear. It is mild in manner, gentle and inoffensive, extremely timid, and most easily trapped. It is to some extent gregarious, as many as fourteen or fifteen sometimes being found in the same burrow.

As Fig. 49 shows, the burrow generally has an entrance which is marked by a little heap of excavated earth. This leads down into the nest where food is often stored.

saepe exiguus mus
Sub terris posuitque domos atque horrea fecit.
(Virgil, *Georgics*, i. 18 b.)

At the other end of the nest there are gene-

rally a couple of bolt-holes separated from one another by an angle of nearly ninety degrees.

> The mouse that always trusts to one poor hole
> Can never be a mouse of any soul.
>
> (Pope, *The Wife of Bath.*)

The field-mouse is prolific, the female pro-

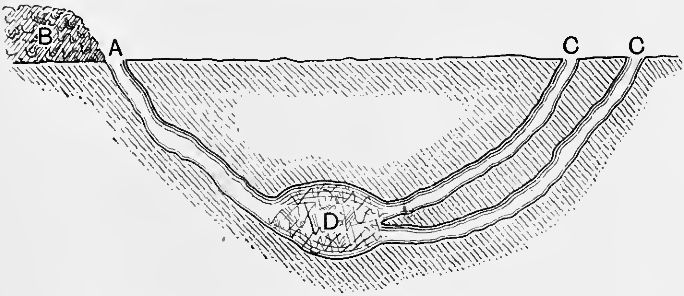

Fig. 49.—Diagram of burrow of field-mouse.

ducing several litters throughout the greater part of the year. The mother carries the young-born litter about for two or three weeks, nipping the skin of her offspring at the side, half-way between the fore and hind legs. The average number of young born at one time is probably somewhere about five, though litters of nine are by no means unknown. All predaceous animals naturally eat field-mice, and they are the favourite food—at any rate, in some localities—of owls.

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